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ARTICLES

LARVICIDING FOR THE CONTROL OF MALARIA MOSQUITOES [1]

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The problem of malaria control has many approaches, some of which have been greatly advanced during the war years. Much progress has been made in the prophylactic and therapeutic use of new and established anti-malarial drugs. One of the most striking advances has been the use of DDT (dichloro-diphenyl-trichloroethane) to combat adult mosquito vectors, by the use of residual house sprays. In spite of many new approaches to the problem and startling advances in traditional procedures, the attack on the vector during its larval stage of devleopment continues to be an important method of malaria control, and recent progress of considerable importance has been made in the methodology involved.

There are certain difficulties which, so far, have prevented the attainment of the spectacular long residual larvicidal sprays that have characterized adult DDT sprays. DDT-oil treatments are nearly as toxic to other aquatic insects and to fish as to mosquitoes so that overdosing must be avoided. The low dosages that are safe to use must be uniformly distributed over the surface of the water to produce uniform larval kills. A surface film of DDT-oil is readily broken up by wind and wave action under usual circumstances. These small quantities of DDT are readily adsorbed by the organic constituents of the bottom mud.

On the other hand, DDT is toxic to mosquito larvae in extremely low dosages. In tests at this laboratory, one part of DDT in one hundred million parts of water killed over 50 per cent of insectary-reared larvae in twenty-four hours. In field studies 62 per cent control was obtained with as little as one one-thousandth of a pound of DDT per acre of water surface. However, if less than 1/20 of a pound was used the results were usually erratic. This dosage as applied by hand consistently produced better than 90 per cent control of all instars of larvae, killing the first instars as efficiently as the large larvae. It is not appreciably effective against either eggs or pupae. Indications are that it may kill appreciable numbers of adults as they emerge from the pupal case but field evidence on this point is lacking. Laboratory observations indicate that the DDT does not deter gravid females from ovipositing and such eggs definitely do hatch, and may survive if the DDT has been dissipated by the time of hatching. It is not known whether or not such ovipositing adults receive a lethal dose in the process but this is doubtful.

THE GALLON DDT-OIL FORMULA

A technique has been developed to permit the efficient and practical dispersal of small quantities of DDT solution which promises to replace a large proportion of the older oiling and even paris green

[1] From Communicable Disease Center (Technical Development Division), Bureau of State Services.

[2] Now with the University of Washington, Seattle, Washington.

dusting. The hand method requires inexpensive and readily available equipment and permits considerable savings in labor. In brief, the technique involves the use of a small (1½- to 4-gallon capacity) air pressure sprayer with suitable nozzle to atomize the DDT-oil solution, permitting the wind to carry the mist 30 feet or farther.

The sprayer can be any one of several compressed-air sprayers now on the market for garden or home use. The larger models, up to 4-gallon capacity, permit the treatment of two to three acres without refilling; the 1½-gallon model permits the treatment of only about one acre without refilling, but its light weight and convenience is apt to more than offset the more frequent trips to the supply truck for refilling. It should be filled not more than two-thirds full to permit sufficient air space for pressure. The pressure can be developed either by a built-in hand pump which is standard equipment on all such sprayers, or if desired, a tire valve may be welded into the top of the tank and the pressure can be obtained from a power compressor or spark plug adaptor when convenient.

The pressure should be initially 50 pounds per square inch and should not be allowed to drop below 30 psi. A petcock valve welded into the top of the tank permits the release of the air pressure before opening to refill, or at the end of the day. Opening the sprayer under pressure is harmful to the gaskets and may cause injury to the operator if the pump is blown out with sufficient force. All gaskets should be of oil-resistant material to minimize the frequency of replacement.

The nozzle is the key to the satisfactory dispersal of low volumes of solution. It should produce a uniformly small particle mist and deliver about three gallons per hour at a pressure of 40 psi. Several companies now have nozzles on the market that meet these specifications. They were originally designed for injecting fuel into oil burners of various types. The type of spray pattern is not important but the usual solid cone is entirely satisfactory.

The solution used consists of an appropriate amount of DDT (such as 0.625 per cent w/v) dissolved in a suitable fuel oil or diesel oil. Kerosene or No. 2 fuel oil is satisfactory. It is essential that the oil be clean to avoid unnecessary clogging of the very-fine-aperture nozzle. Since an entire acre of water surface is to be covered with a single gallon of solution, it is considered desirable to add a small amount of a suitable spreading agent. This insures good distribution of the film, even under difficult conditions such as a dirty water surface or dense vegetation. One-half of 1 per cent of *Triton B-1956*[3] has been found to be quite satisfactory though others are acceptable and it is believed that it would be possible to improve on any that have so far been tested.

The technique employed in a swamp or large shallow pond involves testing the wind direction and velocity by means of a short burst of spray. Paths are then mentally delineated across the pond at right angles to the wind direction and about 30 feet apart, designed to cover the entire breeding surface. Starting at the windward edge of the pond and walking somewhat back from the water's edge, the operator moves at the rate of about 75 feet per minute (that being about the tempo of a slow wedding march) holding the nozzle at a height designed to permit most of the mist to settle within a distance of thirty feet. If the wind is strong the nozzle will be held quite low and the first path may have to be several feet back from the water's edge. If the breeze is very gentle it may be necessary for the operator to hold the nozzle high above his head and possibly even walk in the water for the first swath. Having completed the first swath, the operator should walk downwind about thirty feet and again cross the pond at right angles to the wind, using the same technique as before, continuing with such 30-foot swaths until the entire area is covered.

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[3] A proprietary spreader manufactured by the Rohm and Haas Co., Philadelphia, Pa.

Care should be taken to repump whenever the pressure drops to 30 psi and to refill as necessary. It should be noted that the mist cannot always be seen for a full thirty feet but an experienced operator can judge how far it is traveling from the height and speed of the mist when it disappears. Moreover, it is often possible to see the oil film spreading on the water's surface at a distance of thirty feet if the light is just right. Often the mist will carry much farther, but if allowed to do so the dosage on the first swath will be light unless a slower pace is used. With even the gentlest breezes a 30-foot swath seems to be attained.

In deeper ponds, a boat can be used in place of wading and in some cases it is most practical to drift the mist for fifty to one hundred feet over an inaccessible channel by reducing the pace or retracing one's path.

In the case of narrow ditches the operator can walk along the windward bank, standing back far enough to insure that the mist is not over-shooting the water. If the banks are overgrown, the operator can wade down the center of the ditch moving the nozzle from side to side and keeping it low.

In all cases it is possible to keep clearing operations to a minimum because the fine mist spray will penetrate quite dense vegetative cover and the 30-foot swath permits sufficient flexibility for the operator to walk around obstructions.

In view of the desirability of an intelligent operator, and the compactness and convenience of the lightweight equipment, it should be possible in many cases to dispense with larviciding crews, permitting the controlman to check his known breeding areas by dipping and, when anopheline larvae are found, treating immediately. In such a way it should be possible for one or two good men to accomplish as much malaria control during the season as an entire dusting or oiling crew together with their foreman or supervisor. Moreover much unnecessary clearing could be avoided, further reducing the labor cost. Another important saving of this method over the use of paris green is that the DDT kills all stages of larvae including the small first instars, thus permitting a delay of several additional days before respraying should be necessary. Actually, combining in the one man the functions of checking infestations and spraying permits applying the treatment only when needed and avoids routine treatments when they are unnecessary. It often makes one trip to the pond suffice when two trips would be necessary under the traditional procedure. All of these savings in labor and efficiency make the not inconsiderable savings in cost of material seem incidental.

Recent reports from two months' use of the DDT-oil mist technique in eleven areas in Arkansas,[4] using slightly more than one gallon per acre, indicate the method to be equally as effective as straight oil larvicides, with the added advantages of greater ease in application and striking savings in labor and material costs. The following advantages and disadvantages of the method were reported, as a result of its first large scale practical use in mosquito control.

Advantages

1. Reduction of material costs ranging from 63 to 90 per per cent.
2. Savings in labor costs ranging from 20 to 80 per cent due to increased spray swath and less frequent refilling of cans.
3. Greater penetration of thick vegetation.
4. Less labor fatigue with the handling of lighter cans (2½ gals. instead of 5 gals.).
5. Loading time is reduced by use of concentrates.
6. Less chance of spillage and subsequent blistering to men.
7. Extremely long ditches may be finished without refilling.

Disadvantages

1. Requires better-trained control men.

[4] The Arkansas Malaria Bulletin, Arkansas State Board of Health, 2: No. 3, 1–3, July 1, 1946.

2. Since mists are essentially wind-borne, success or failure of a treatment is due to type of breeze and proper application techniques.
3. Treatments have little effect on pupae.

A typical quotation from the report states: "Heavy breeding found in one area which had not been larvicided. After treatment with DDT enriched mist larvicide, breeding dropped to zero. Larval and adult station counts are 5 to 10 per cent lower than in 1945." Success with the use of the technique comes with proper training and experience.

AIRPLANE DISPERSAL OF DDT

The newer developments in airplane application are as important even though they do not involve so many different savings. In general, two types of airplane equipment have been developed for dispersal of DDT solutions.

Spraying equipment has involved a variety of details but in most cases, at least with the smaller planes that are apt to be more practical for peace-time use, the solution of DDT is pumped out of the storage tank through one or more nozzles which are designed to atomize the spray. Some nozzles have sufficiently small apertures to produce a small particle-size simply as a result of the pressure of the pump. Others are designed to make use of the air speed of the plane to break up the droplets. In some equipment the discharge from the nozzles impinges on a breaker bar which helps to break up the droplets. In all cases the mist produced is practically invisible unless the light is just right, so that the pilot cannot use the mist itself as a marker in delineating his lines of flight.

The second method has been labeled a "thermal aerosol" though there is some question as to the accuracy of the use of the term "aerosol" with droplets of the size actually obtained by this equipment. In this case the DDT solution is pumped from the storage tank into a venturi that is attached to the exhaust line of the engine. The heat from the engine breaks the droplets into a very small size and actually burns enough of the solvent to produce a dense white smoke which is mixed with the exhaust gases and is released into the slip-stream of the plane. This white cloud is readily visible for a considerable distance. It cannot be relied upon as a satisfactory marker, but it gives the pilot a method of checking to make sure that his equipment is working properly and that the cloud is going where it should.

The advantages of the spray nozzles are that they produce somewhat larger droplets that will settle faster and thus permit flying at a slightly higher elevation or with a stronger breeze. The thermal aerosol is preferred by some because it produces smaller particles that will give a wider and more uniform swath and better penetrate vegetative cover, and because the visible cloud acts as a positive and immediate check on faulty equipment or dispersal.

With both types of equipment it is desirable to use a solution containing as much DDT as is practical to handle and a solvent that is not too volatile and not too inflammable. Certain high boiling methylated naphthalenes have proved very satisfactory and permit the use of 20 per cent of DDT. Since in our tests a discharge of 0.1 pound of DDT per acre normally gave good larval control, one gallon of solution should treat about 17 acres. A typical plane that has been used successfully for such purposes is the Stearman PT-17, an open cockpit biplane, that cruises at about 85 to 90 miles per hour. A swath width of at least one hundred feet can be obtained, flying at about 30 feet above the water. If the system is calibrated to discharge one gallon per minute, 30 gallons of solution, which can be carried in a modified rear cockpit, will suffice for treating at least 500 acres in one-half hour, not counting time lost in turning. A typical spray operation required 25.1 gallons and 55 minutes flying time to treat two ponds totaling 455 acres, with no reloading. This is a considerable saving in both flying and reloading time over the older dusting methods. The efficiency of

the control so obtained has been adequately checked and has been found satisfactory.

DDT Dusts

At the present time DDT applied as a dust has little advantage over paris green. Since it is approximately ten times as toxic as paris green, a 1 per cent DDT dust is comparable to a 10 per cent paris green dust and can be applied in similar equipment at the same total rate per acre. The chief difference is that DDT should never be diluted with lime since alkali may decompose DDT by a process of dehydrohalogenation. DDT dusts have been notable in that they have been appreciably less toxic to fish and fish food organisms than the other forms of DDT tested.

Technical DDT has such gummy physical characteristics that it cannot easily be mixed with a diluent for dusting. It must have some sort of conditioner added and the process is such that it is impractical except on a commercial scale. Most malaria control agencies would prefer, therefore, to buy one or another of the commercially available dust concentrates. They are available with DDT concentrations ranging from 10 per cent up to 40 per cent or even higher. These concentrates may be further diluted with inert carriers in any simple dust-mixing machinery. It is possible that methods may be worked out to permit the application of a dust concentrate at a lower rate per acre, but at the present time it seems best to use a 1 per cent concentration of DDT and apply from five to ten pounds of finished dust per acre. Hand dusting equipment has, unfortunately, not been changed appreciably during the war. In general, wartime research has been more concerned with developing entirely new types of equipment, particularly for the application of small-particle mists and aerosols, rather than with the improvement of dusting machinery.

Equipment

Some of the new dispersal equipment developed during the war is quite spectacular. Military fog generators, used for producing smoke screens, have been modified to permit the incorporation in the fog of finely divided droplets of a DDT solution. Such generators are usually mounted on some type of truck for mobility. They depend upon the ignition of gasoline under forced draft for heat and so are quite noisy. The combination of the roar of the generator and the large clouds of smoke billowing from the discharge nozzles and being borne away by the wind is at least spectacular. The temperature of the discharge, which is automatically controlled, can be adjusted to give a relatively wider range of particle sizes. The most important limitation of the equipment is that it is so dependent upon proper meteorological conditions. Thus, the direction in which the cloud drifts is determined by wind direction; the distance that it is carried and the rate of deposition of DDT are determined by wind velocity and temperature on the ground as compared with the temperature at an elevation of six feet above the ground. Changing the particle size by adjusting the temperature control permits limited adjustment for wind velocity, but is a poor substitute for conditions of inversion.[5] Under ideal conditions the equipment can generate a DDT smoke that will kill anopheline mosquito larvae for a distance of several hundred feet; but since those ideal conditions are not too commonly encountered, it appears that this type of equipment is more apt to find a place in agricultural pest control or in the control of adult flying insects.

Another group of spectacular equipment has been developed under the general subject of pyrotechnics. These were designed primarily for use under combat conditions and it appears likely that their usefulness will be mostly restricted to military larviciding. Mortar shells containing DDT, DDT-containing bombs to be dropped from aircraft, and hand grenades or

[5] Temperature inversion is defined as the condition in which ground temperature is lower than air temperature; it results in downward air currents.

candles containing DDT are methods that may permit the application of DDT to otherwise inaccessible breeding areas, but they are very inefficient and their usefulness in peacetime malaria control is doubtful.

There has been little progress made on developing power equipment for ground aerosol dispersal other than the fog-generating machines described above, but this type of equipment has not proved too satisfactory for larvicidal use.

DDT EMULSIONS

If DDT is dissolved in fuel oil or another solvent and an oil-soluble emulsifier added, it can be emulsified in water and the dilute emulsion can be applied at 15 gallons per acre or some other convenient rate. This technique makes use of the older and awkward knapsack sprayers, or of power sprayers either from truck or boat. Some workers have experimented with the use of a small quantity of DDT-oil solution dispersed through boat-mounted pumps which mix the solution with water pumped from infested lakes, and discharge it through nozzles for a considerable distance.

Any of these methods should give satisfactory control of anopheline larvae and also of most culicine larvae; but there is always increased danger to fish and other aquatic organisms when the DDT is dispersed throughout the water, as it is when applied as an emulsion, rather than spread over the surface as a film. Therefore, in any such formula the emulsion should be as quick-breaking as possible and the dosage should be kept to the minimum of 0.05 pounds of DDT per acre. These methods cannot be recommended for indiscriminate use where fish or other aquatic wildlife are very important until more is known about them.

SUMMARY

In summation, DDT has not produced the spectacular residual effects against larvae that it has against adult mosquitoes; but due to the high toxicity obtained from minute amounts, it has permitted the development of new methods of larviciding, both by hand and by airplane, which give promise of displacing in large measure the older techniques of oiling and paris green dusting.

In experimental field tests the application of one gallon of fuel oil with 0.05 pound of DDT per acre has given excellent larval control, with evident savings in costs of labor and materials.

RECENT TRENDS IN MALARIA CONTROL IN LATIN AMERICA

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INTRODUCTION

During the period of 1942–1946 the author was assigned as Chief of Field Party of the Institute of Inter-American Affairs to El Salvador, C. A., for one year and, subsequently, for three years to Mexico. During the former experience, opportunity was afforded for visits to other Central American countries. More recently the International Health Division of the Rockefeller Foundation made possible a tour of malaria control activities in certain Caribbean and South American

countries, including Trinidad, Venezuela, Colombia, and Panama.

Undoubtedly World War II provided a great incentive for investigations on the possibilities of control of malaria. The discoveries of more effective insecticides, such as DDT, gammexane, 1068, et cetera, the application of these materials as adulticides in the form of residual house sprays, and the combined efforts under the Committee for Coordination of Malaria Studies in the research for new chemotherapeutics have permitted rapid strides in malaria control work during this interval.

MALARIA PROBLEM IN LATIN AMERICA

The special conditions existing in tropical regions of the world contribute toward increasing the malaria problem as compared to that existing in more temperate climates. Some of these contributing factors are unusually heavy seasonal rains, the widespread use of irrigation, poor housing and poor nutrition, the almost universally low economy, and frequently the year-round breeding season of the vector. Faust (1941) in discussing the distribution of malaria in Mexico, Central America, and the West Indies states that the computed average malaria mortality rate for all of the tropical countries considered in his paper (with a reported population of 38,500,000) is 166 per 100,000 population, a figure probably far too low. This means that approximately 63,900 deaths are caused each year by malaria in this region.

The writer was greatly surprised shortly after his arrival in El Salvador in making malaria surveys in company with Dr. Arnoldo Sutter to encounter spleen rates of 88 per cent in Acajutla and 83 per cent in Sonsonate during the dry season (March). Parasite rates were 36 per cent and 26 per cent respectively. Not only were these rates high, but a considerable portion of the cases of splenomegaly were in classes 3 and 4, with very few PDI or in class 1. In neither of these communities was there evidence of epidemic malaria at the time of the survey. Subsequently, there was an experience in Mexico where, following a tornado in September 1944, widespread malaria epidemics occurred in the region of the Isthmus of Tehuantepec and the coastal portions of the State of Veracruz, which also emphasized the importance of the disease. The prompt utilization of atabrine as a therapeutic and prophylactic permitted the rehabilitation of the damaged areas.

It is still generally admitted that in the tropical Americas malaria is public health problem No. 1, despite the fact that notable progress has been made in recent years and that the future is very promising.

EARLY DEVELOPMENTS IN MALARIA CONTROL IN LATIN AMERICA

The experience gained in the construction of the Panama Canal shortly after the beginning of the present century demonstrated that while malaria is a terrible scourge which, if uncontrolled, may frustrate man's plans, it can be brought under control by appropriate measures, carefully enforced. The maintenance of control procedures has been demonstrated as feasible in this location. The historical experience in Panama has not been accompanied, however, with very significant similar efforts in adjoining regions. Undoubtedly the high cost of these control measures has not permitted their widespread application.

In connection with drainage for malaria control the experience in Panama has been very fruitful. The widespread utilization of permanent ditch lining has progressed to the point that the "Panama" invert has been adopted in many other places.

CONTROL

1. *Permanent Elimination of Breeding Places*

(A) *Drainage*

As referred to above, the necessity for utilization of some form of permanent ditch lining has been adequately demonstrated in Panama. The utilization of precast or cast-in-place structures for the permanent lining of drainage canals is of

great importance in the tropics. Excessive rainfall which may be of short duration, combined with fertile soil, makes their use imperative in lieu of costly continuing maintenance.

Along with the necessity for permanent ditch lining, there are a number of special requirements which must be utilized under particular circumstances; to mention only a few, the question of the sodding of the slopes of ditches, the clearing of right-of-way to prevent vegetation from overgrowing the canals, and the provision of overpasses for livestock and carts, or special crossings.

In many instances it is possible to combine agricultural drainage or land reclamation with malaria control drainage. The removal of storm water or sewage can frequently be integrated with malaria control drainage. The city of Maracay, Venezuela, demonstrates an excellent example of the expansion of residential districts made possible through drainage of swamps. At Sonsonate in El Salvador irrigation was combined with malaria control drainage, a project undertaken by the Servicio Cooperativo Inter-Americano de Salud Publica. In this region the transmission of malaria was occurring on a year-round basis through the production of *Anopheles albimanus* in ponded areas during the wet season and was associated in the dry season with the use of irrigation water where adequate provision was not made for the run-off of the surplus. It was possible to design the canals so that they are utilized for drainage purposes during the rainy season and to carry water from a spring to be used for irrigation purposes in the dry season, but it was necessary to provide for the carry-off of the residual from excessive irrigation.

In Venezuela the opportunity to combine highway drainage and malaria control drainage was observed recently near Valencia. Here, as in other instances, the initiative was taken by the Health Department rather than by highway construction.

Special situations, such as the utilization of construction of drainage outlets across sand bars, have necessitated the protection of the outlet to the sea. Newbold (1943) has described a sea head for coastal swamp drainage. The sea head projects into the sea with two side openings at right angles to the long axis of the structure. The scouring action of the waves keeps the outlet unobstructed and free of sand. An example recently seen at Patience Bay, Trinidad, was functioning satisfactorily.

(B) *Diking and Dewatering*

The construction of dikes and the installation of pumps to dewater the diked area has been utilized in various parts of the world as a malaria control procedure. It is particularly applicable in coastal areas where sufficient gradient is not available for gravity drainage. During the recent years there has been considerable extension of this measure on the island of Puerto Rico.

(C) *Filling*

As mentioned above, the town of Acajutla, El Salvador, has an intense malaria problem which in certain surveys has been revealed as high as 96 per cent splenomegaly among the school children. This town with a population of approximately 1,500 has had previous to 1942 more deaths than births. The principal cause of mortality was malaria. This important port maintained its population through immigration, but the supply of labor was constantly being decimated through malaria. The principal sources of *A. albimanus* breeding were fresh-water ponds in the rear of the sand bar on which the town is located. Through a cooperative arrangement with the railway and port authorities, the Servicio Cooperativo undertook the filling of these breeding places. Atabrine was administered temporarily to the labor forces. Even prior to the completion of the filling work, a marked improvement in labor was noticeable, and it is believed that extension of the work would practically eliminate the vector from this town.

Filling has been used quite extensively in many countries of Latin America. In Panama in connection with the excavation for the canal extensive swamps were filled. More recently in Venezuela this malaria control measure has been utilized at Ocumare de la Costa and previously in Turriama.

Not only does this measure result in the permanent elimination of breeding places of the malaria vector, but it also leads to land reclamation which may play a very important part in the development of cities. One of the largest projects under consideration is about to be initiated in Barranquilla, Colombia, where an area adjoining the river extending for several miles is at present flooded during the major portion of the wet season, resulting in heavy production of *Anopheles albimanus* and preventing the proper industrial development along the river front. The increase in land values will more than repay the anticipated cost of the hydraulic fill of this particular project.

Although not extensively utilized to date, proper disposal of garbage through sanitary fill may be used to eliminate extensive swamps about cities. This sanitary procedure, however, must be carefully controlled, or it may lead to the creation of a health nuisance.

2. *Larvicides*

While scientifically conducted experiments with oil as a larvicide were first published by Howard in 1892, probably the earliest wide-scale demonstration of their application in malaria control was made in Panama during construction days of the canal. The formula utilized there was as follows:

> 200 lbs. of finely crushed resin mixed with 15 gallons of crude carbolic acid; 30 lbs. of caustic soda dissolved in 6 gallons of water are added to form an emulsion.

Various formulas of oil have been utilized in Latin America, particularly in countries having petroleum deposits. The repetitive, costly nature of this procedure has prevented its wide adoption.

Similarly, Paris green has been used as an anopheline larvicide and is still being used today as, for example, in Panama, where the cost of weekly applications has prevented its widespread use.

The discovery of DDT as a larvicide led to its prompt adoption, and some of the earliest work in the distribution of DDT by airplane was carried out in field tests in the Canal Zone during the recent world war. Despite the fact that it is cheaper and more effective than the older established larvicides, so far as is known it has not yet been adopted in extensive Latin American areas.

3. *DDT Residual House Sprays*

Following the field trial of DDT in the United States, as reported by Gahan and Lindquist (1945), at Stuttgart, Arkansas, the effectiveness of DDT residual spray, in a rice-growing area in Mexico where *Anopheles pseudopunctipennis* is the vector, was tested by Gahan and Payne (1945). These latter authors found that not only was there a marked reduction (99.9 per cent) in the number of adult mosquitoes in the treated area but there was also a considerable reduction (89 per cent) in the larvae in the breeding grounds immediately adjacent to the treated region as compared with untreated control villages.

Trapido (1946) reports upon the effect of residual spraying of dwellings with DDT in the control of malaria transmission in Panama, with special reference to *A. albimanus,* as carried out in a highly malarious area which has been under continuous study for 15 years and where conditions are excellent for the sustained production of large numbers of the malaria vector. *A. albimanus* does not normally rest in houses during the daytime. In this experiment the exterior and the interior of all dwellings (native huts) were sprayed. The study revealed that not only was there a large reduction in the numbers of mosquitoes in treated dwellings, but also that among those taken in these dwellings there was a marked reduc-

tion in the percentage engorged (since DDT activates the insect and it loses interest in feeding) and that among the engorged mosquitoes the 24-hour survival rate was low for a period of 3 months after treatment. A marked decline in the malaria rate was observed, the cumulative index being 14.8 per cent for the year 1945 in the sprayed village and 52 per cent for the same one-year period in the control villages.

Stephens and Pratt (1947) present the results of their first year's observations of DDT residual spraying of a village in Puerto Rico. In the treated village there was a progressive decline in the percentage of positive malaria slides from 5.8 per cent in the "rainy season" of October, 1944, to 2.8 per cent in the dry season of March, 1945, and, most significantly of all, to 0.91 per cent during the "rainy season" of October, 1945. The control village followed approximately the normal cycle for Puerto Rico with 4.7 per cent positive for malaria during the "rainy season" of November, 1944, decreasing to 0.51 per cent positive during the "dry season" of March–April, 1945, having a marked increase to 3.8 per cent positive during the "rainy season" of November, 1945. In the treated village the first residual spraying was done in November, 1944, and the second in June, 1945.

Extensive investigation of the efficacy of DDT as a malaria control procedure has been observed recently in Trinidad, Venezuela, Colombia, and Panama. It is known to be under investigation in a great many other countries of tropical America. This new approach to the control of the vector offers for the first time an adequate measure applicable to a wide variety of conditions, not prohibitively expensive, enthusiastically received by the public, and providing wide utility in a public health program, including the control of flies, *Culicoides, Phlebotomus,* lice, fleas, and other arthropods important in the transmission of disease. In small towns and rural areas where the permanent elimination of breeding places cannot be undertaken in view of its cost, DDT as a residual spray would seem to hold greater promise than any other malaria control procedure developed to date.

4. *Herbicidal Work*

Recent interest in the United States in the application of hormone type herbicides, such as 2,4-D, for the control of aquatic vegetation is particularly promising in the field of malaria control (Hall and Hess, 1947). Its applicability to tropical conditions apparently has not been adequately tested.

One instance of reliance on herbicides as a malaria control procedure may be cited from Trinidad. Extensive use is being made of ½ per cent solution of copper sulphate in the control of epiphytic plants which harbor *Anopheles bellator.* The immortelle trees in the cacao-producing area of Trinidad harbor large numbers of bromeliads. One particular species of *Gravisia* frequently harbors *A. bellator.* The selective spraying of this bromeliad utilizing the gypsy moth sprayer has given satisfactory results. While the treatment is expensive, it has a rather lasting value. No regeneration has been reported over a period of 5 years.

5. *Naturalistic Measures*

Carr (1938) in Cuba experimented with the possibility of limiting *A. albimanus* breeding by shading the streams. He states that natural bodies of water which are well shaded and which are provided with predacious fish are unfavorable for mosquito breeding, due to the fact that horizontal and other vegetation does not flourish under these conditions and, therefore, the larvae have no protection against their natural enemies. He utilized *Ficus benjamini* for the production of shade. He also produced artificial shade by constructing a palm leaf thatched roof over a section of a small stream. Prolific *albimanus* breeding was present in floating algae at the initiation of the experiment. After the roof had been in place for one

month, the filamentous algae and anopheline larvae had disappeared from the shaded portion of the stream.

It does not appear that any extensive utilization has been made of the introduction of artificial shade in the control of malaria mosquitoes in Latin America. It is, however, a frequent observation that densely shaded areas, such as heavy growth of sugar cane, may not prove attractive to certain anopheline vectors in this region of the world.

Earle studied the utilization of intermittent irrigation of rice fields in Mexico as a control measure for *Anopheles pseudopunctipennis*. It was found that where the cooperation of the rice farmers could be enlisted the procedure was effective in the prevention of the transmission of malaria. As a result of these investigations, certain legislation was adopted either restricting the growing of rice in close proximity to densely populated areas or requiring the employment of intermittent irrigation so that a period of drying of sufficient length to kill the anopheline larvae resulted.

Other naturalistic measures have received considerable study in Latin America. The employment of predacious fish, such as *Gambusia,* has probably been most widely adopted. In general, however, it seems that the employment of naturalistic measures is of rather limited utilization and has never been widely adopted for a variety of breeding situations.

Certain use of automatic siphons has been made in Latin America (e.g. in Granada, Cochrane and Newbold, 1943). In Trinidad in one situation a dam and automatic siphon have been constructed to produce a flushing out of a stream in control of mosquito breeding. This particular siphon has been designed to provide flushing of the stream during the dry season when pooling of water in the stream bed creates satisfactory breeding places for *A. aquasalis*. The initial installation was stated to cost approximately $3,000, and effective flushing range of 2½ miles downstream from the siphon is provided.

6. *Chemotherapy and Chemoprophylaxis*

Clark and Komp (1941) over a period of 10 years carried out an experiment in the control of malaria with drugs alone where no antimosquito measures were used. While it was shown that the average annual rate for the treated villages showed a decline from 21.6 per cent to 12.1 per cent over the 10-year period and that a comparable decrease was not noted in the control groups, the study brought out the limitations of relying on drugs alone in the control of malaria. In the authors' opinion, quinine sulphate and atabrine were of equal therapeutic value.

During the war a total in excess of 12,000 drugs were tested as antimalarials, and as a result of these investigations two or three show considerable promise. In the Americas the most critical tests have been carried out with chloroquine. Chloroquine as a suppressive appears to be at least as effective as atabrine when administered as one pill (0.15 grams) once weekly. Furthermore, it has the decided therapeutic advantage that a course of treatment does not exceed 3 days' duration and is not accompanied by any discoloration of the skin. Experimentation that is now in progress with this drug in Panama, Colombia, and other Latin American countries will undoubtedly point to the exact place which this drug may assume in a malaria control program. In highly endemic areas it would seem that some consideration to the treatment of the "seed bed" of malaria must be given in addition to the utilization of DDT house residual spray. If this is not given, the individuals will continue ill of malaria and subsequently may have numerous relapses, particularly in the case of tertian or quartan malaria. On the other hand, if a single course of treatment can be administered over a 3-day period and some minimum provision be made for the follow-up either through weekly suppressive dosage or for retreatment of those who break through with relapses, the antimosquito measures, such as DDT residual spray, may be relied upon to prevent new transmission of malaria.

SURVEYS

Information on the distribution of anophelines in Latin America has been accumulated over a period of years. Rozeboom (1941) summarized the distribution data concerning *Anopheles* mosquitoes of the Caribbean area. In the United States information on the distribution of *A. quadrimaculatus* can readily be obtained from inspections of stables or dwelling places. In Latin America, with the exception of a few species, such as *A. darlingi,* many of the important vectors do not rest during the daytime in dwellings. It has, therefore, been necessary to make extensive use of various types of traps. The animal-baited traps devised by Earle, Magoon, and others have been particularly effective as regards captures of *A. albimanus.* The "Shannon-dawn" trap as observed in Trinidad has certain advantages over the former types of traps. In the island of Trinidad it has proven particularly helpful in the capture of *A. aquasalis.* Data from Puerto Rico and Colombia indicate that the New Jersey light trap may be useful in determining density of *A. albimanus.*

RESEARCH

Until recent years research on malaria in Latin America has been mainly limited to surveys to define the malaria problem and to incriminate the local vector. Neither funds nor trained personnel were available for the basic research which forms such an important part of malaria control programs. Through the cooperation of the International Health Division of the Rockefeller Foundation and more recently the Institute of Inter-American Affairs, local Health Departments in Latin America have been able to devote much more attention to basic research. It is believed that more careful investigations will not only lead to a better definition of the problem but will also evolve more effective means to resolve it.

No attempt within the scope of this present paper will be made to summarize the very extensive dissection studies that have been carried on in Latin America to incriminate the various anopheline vectors of malaria. In the main, it may be stated that a certain amount of information is available concerning the percentage of the suspected vectors positive upon examination of stomachs and glands. In certain individual countries it may be said that this information is relatively adequate. On the other hand, in other places it is totally inadequate.

Similar statements may be made about the blood and spleen surveys for malaria. The activity of the International Health Division of the Rockefeller Foundation and, during the last 5 years, of the Institute of Inter-American Affairs has given great assistance to the individual countries in determining the exact status of malaria.

TRAINING

The Dirección de la Malariología of Venezuela has excellent facilities for training in its headquarters building in Maracay. Adequate classroom and rather complete laboratory facilities for 32 students are available. Annually one formal course of 4 or 5 months' duration is given at Maracay, followed by field training for doctors, engineers, and inspectors. Venezuela has accepted trainees from other Latin American countries, and the facilities are excellent for this purpose. The advantages of instruction to students in the Spanish language and in an environment similar to that in their own country are obvious.

At the Institute of Tropical Medicine in Mexico City there are excellent facilities for research. Recently interest has been aroused in training in tropical medicine, and a special course of malariology has been given at times. There are splendid opportunities in Mexico also for field training, particularly since special centers, such as the Boca del Rio Health Center and Tropical Medicine Training Station and the Onchocerca Center at Huixtla, have field demonstration and training facilities.

The Puerto Rico School of Tropical Medicine and Public Health also provides opportunities for training in general tropical medicine.

It is to be hoped that more countries of Latin America will begin to provide facilities for the training of their own personnel and possibly for the reception of trainees from adjoining countries which do not have these facilities.

FUTURE OUTLOOK

In a considerable number of countries of Latin America real progress has been made in the control of malaria about the important cities and larger towns. In the main, this has been through permanent elimination of breeding places of mosquito larvae. Less attention has been given to the smaller towns and rural areas. The advent of DDT residual spray is a promising event for these more sparsely populated areas. The exact place of this measure in the prevention of the transmission of malaria probably remains to be defined. It appears certain that this procedure will have many beneficial side effects through control of other arthropods which are vectors of disease in the tropics. The availability of certain of the new chemotherapeutics and chemoprophylactics is increasingly promising. Again, the exact position that they may attain in a general malaria control program has not yet been delineated. The increasing attention being focused on research in the field of malariology is one of the most promising fields of development in the American tropics today.

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THE SEPARATION OF MOSQUITO CATCHES FROM THE NEW JERSEY LIGHT TRAP

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In the course of the Pennsylvania Mosquito Survey for 1947 (a part of the Ecological Insect Survey of Pennsylvania) methods of separating and counting of mosquitoes from New Jersey light trap catches came under critical scrutiny. In the county mosquito control commission investigated, a method of separating was used which the writers believe is more or less like that used in most similar organizations.

In the particular case under discussion, the person originally handling separation alone was not a professional entomologist, but was a semi-skilled worker with long experience in the job of segregating mosquitoes from the matrix of other insect bodies in the catch. The method used was as follows: the trap collection was spread as thinly as possible over a light colored blotter. The mosquitoes (females only) were then picked out, usually using the naked eye and forceps, and segregated for identification to species by another worker. One catch from a commission trap at the end of June filled approximately seven cubic inches of space when loosely packed. A routine twenty minutes' "spread-out" sorting yielded 13 female mosquitoes.

The junior author, wishing to separate the males, took the residue, after supposed removal of all females, to the Survey Laboratory at State College. Sorting by the spread-out method, he was surprised to find, besides the sought-for males, 32 additional females. The residue was turned over to Dr. S. W. Frost, the Director of the Survey, for subjection to his "breakdown" method.

In this method, the total light trap catch is broken down into some 30 or 40 categories—to orders, families, and in a few cases, to species—all done in the first separation by pigeon-holing each category into small receptacles. The separators are skilled or semi-skilled and all have had biological training. Low magnification is used constantly. The larger insects are carefully examined to make sure that no smaller insect may be hidden in folds of wings or legs. With care exercised, this method yields 100 per cent of any category of insects but the very smallest; mosquitoes are not small when compared to some of the *Cecidomyiidae* and other tiny insects.

To shorten this part of the report, then: the breakdown method applied to the catch in question yielded still another 43 female mosquitoes. Nine of the 43 proved to be unidentifiable because without legs, wings or abdomens, but the breakdown picked out even these fragments.

With this information, the senior author selected another large county commission

TABLE 1.

	No. of Females	*% of Total*
1. Spread-out sort by county commission	13	14.8
2. Spread-out sort by State Survey	32	36.3
3. Breakdown sort by State Survey	43	48.9
Total	88	100.0

catch and had the county separator go over it in the routine manner using the spread-out method. He then took the residue and went over it himself, using the spread-out method but exercising special care. The results of the two sorts were as follows, given in approximate percentages:

Table 2.

	% of Total
1. First sort in routine spread-out manner by separator	34
2. Second sort in routine spread-out manner by senior author	50

In a third extremely careful spread-out sort, the senior author believes that he found the remaining 16 per cent of female mosquitoes. The improvement in the first sort by the separator from 14.8 per cent in Table 1 to 34 per cent in Table 2 was probably due to more careful sorting after the special request of the senior author for separation and perhaps also to a difference in the size and composition of the total catch.

In view of the above findings, the county commission instituted new procedures in separation of the catch. The breakdown method was out of the question due to the uneconomical use of time and labor in searching for only one category of insects. Under the new system two men went through the catch in turn, each using the spread-out method with low magnification when necessary and exercising greater care in sorting. A random sample of the residue from such a double spread-out search was again submitted to examination by the breakdown method at State College. Results are as follows:

mosquito control commission. The breakdown method of Dr. S. W. Frost was found to be the most efficient method of sorting, yielding 100 per cent of a given category such as mosquitoes, but the method proved impractical for the sorting of only the one category with a small labor force and a large number of catches. As a compromise, closely supervised double spread-out counts by two different separators counting consecutively was checked and found to yield very good results when performed under low magnification.

The New Jersey Light Trap has the reputation of being a tool of a high degree of standardization. The present writers believe, however, that the methods of counting and sorting employed by various agencies investigating mosquito populations have been woefully non-standard. The following factors are the principal ones affecting full accuracy in separation of female mosquitoes from the non-culicid insect matrix:

1. Composition and size of catch.
2. Perceptual abilities, interest, and alertness of the separator.
3. Differences in methods and tools employed.

This crude study is not intended to set standards of separation methods, but to focus attention upon the methods now in use. Actually, any method or system may be used which yields the ideal 100 per cent of female mosquitoes, or which yields differences from that percentage small enough so that the composition of the mosquito population may be accurately determined.

Table 3.

	No. of Females	% of Total
1. Double spread-out sorting at county commission	183	97.3
2. Breakdown sorting of residue from 1 above	5	2.7
Totals	188	100.0

Conclusions

The spread-out method of separating New Jersey Light Trap female mosquito catches from the matrix of non-culicid insects was found to be extremely inefficient and productive of misleading counts as practiced by at least one county

PRELIMINARY STUDIES OF LARVICIDES ON SNOW-WATER MOSQUITOES

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Snow-water, or mountain, mosquitoes create a nuisance problem to timber and road workers, vacationists, resort owners, and others in many places in the West. The treatment of swales or ponds in mountain areas several months before the melting snow causes mosquito eggs to hatch has been considered for several years, but only since the advent of DDT and other new insecticides has there been much hope for adequate control. Since larval development is usually complete before roads are passable in the spring, control measures against the immature stages are exceedingly difficult. The tests reported in this paper were initiated in Oregon on October 31, 1946, to determine the value of using some of the new insecticides during the fall when roads are open.

Yates and Gjullin (1947) reported that DDT applied at the rate of 1 pound per acre 51 days before flooding was effective against floodwater *Aedes* mosquitoes along the Columbia River. Soil samples taken on plots treated with 3 pounds per acre indicated that some of the toxicant remained in the soil nine months after treatment even though several floods had occurred.

Prelarvicide Tests.—A long, narrow, marshy swale near Diamond Lake known to be a prolific source of mosquitoes was divided into four 1-acre plots and treated with DDT-oil solutions and a dust mixture. Soil samples collected at the time of spraying showed viable eggs to be present. The water was covered with ice 1 inch thick and snow from 1 to 6 inches deep. The oil solutions were applied with a hand sprayer, and the dust was broadcast by hand. Ten per cent of DDT plus 20 per cent of xylene in Diesel oil was used at the rate of 2 pounds of DDT per acre on two plots and 1.6 pounds on another plot. Five per cent of DDT in talc was applied to one plot at the rate of 0.9 pound of active ingredient per acre. Two plots were also treated in the Odell Lake area, one with DDT in Diesel oil at 3.2 pounds per acre, and the other with the DDT-xylene emulsion at 4.5 pounds.

Examinations of these areas were made on May 14, 1947, while the roads were still blocked with snow. Dipping throughout the treated plots (water depth 12 inches) at Diamond Lake failed to show a single larva, but in the untreated areas they were present in great numbers. Even the lowest dosage of 0.9 pound of DDT in dust form gave perfect results. Water samples taken at this time proved to be highly toxic to third- and fourth-stage mosquito larvae. Collections showed 65 per cent to be *Aedes communis* (Deg.), 32 per cent *A. hexodontus* Dyar, and 3 per cent *Aedes* sp.

No larvae were found in the plots located in the Odell Lake area. Although they appeared to be likely areas for mosquito breeding, soil samples taken at the time of treatment failed to show any eggs, and the results are therefore of doubtful value. The plot on which the DDT-xylene emulsion had been applied contained water from 2 to 3 feet deep. The examination of this plot during the spring and summer showed white sheets of DDT on the bottom surface in the exact places where the material had been applied in the fall. Water samples taken from several of the plots at intervals during the summer proved to be toxic to third- and fourth-stage larvae of *Culex tarsalis* Coq. Even 11 months after the treatment water samples gave 95 to 100 per cent mortality of second- and third-stage larvae of *C. tarsalis* and *Anopheles* sp. Presumably some of the DDT goes into solution in the water in an amount sufficient to be toxic to the

TABLE 1. Results of Field Tests with DDT Formulations on Snow-Water Mosquito Larvae in the Cascade Mountains and Near Diamond Lake, Oregon.

Material Used	Dosage of DDT	Tests	Mortality in 24 Hours
	Pounds Per Acre	*Number*	*Per Cent*
DDT, 1.25 per cent in Diesel oil	0.05	5	99
	.02	9	93
	.01	5	92
	.005	3	79
DDT dust, 5 per cent	.2	3	95
	.1	2	94
	.04	2	84
	.02	2	78
	(1 part of DDT to indicated million parts of water)		
DDT-xylene emulsion	125	1	100
	250	4	98
	500	9	94
	750	2	64

larvae. The importance of the long-lasting effect of prelarvaciding treatments for mosquito control in mountain areas is considered great.

Field Tests.—Small-plot field tests were conducted during May and June against mountain mosquito larvae with three formulations of DDT—a solution, a dust, and an emulsion. A high percentage of the larvae were in the fourth instar at the time of testing. About half the tests were made in open and shaded mountain meadows in the Cascade Mountains along the Santiam River, and the others in the vicinity of Diamond Lake over typical marsh areas containing a good growth of grass. The plots ranged in size from 100 to 1,800 square feet, but were much too small to give the best results. With larger plots the drift of insecticide would be minimized. Some of the oil solutions were applied with a Flit gun, producing an atomized spray, whereas a small pressure gun was used for the others.

TABLE 2. Results of Laboratory Tests Which Several New Insecticides Against Fourth-Instar Larvae of Snow-Water Mosquitoes.

Chemical and Concentration (1 part of DDT to indicated million parts of water)	Tests	Mortality in 24 Hours	Mortality in 48 Hours
	Number	*Per Cent*	*Per Cent*
Gamma-benzene hexachloride [1]			
350	2	86	100
500	5	66	89
600	3	39	83
DDT			
350	2	82	100
500	4	57	89
600	4	38	85
Chlorinated camphene			
350	1	64	96
500	4	28	88
600	3	20	52
Chlordane			
350	2	70	98
500	4	22	91
600	4	35	73
Methoxy analog of DDT			
350	1	68	96
500	4	49	89
600	3	31	59
Checks on different lots	3	8	17

[1] 100 per cent made from a sample containing 83 per cent of gamma isomer.

Slightly better results were obtained with the pressure gun, which produced larger particles. The emulsions were applied as a spray and by pouring the material on the water. A small bulb duster was used in applying the dusts. In a few cases the slow movement of water from the treated plots reduced the concentration of the emulsion and no doubt reduced mortalities of larvae.

Samples of larvae taken from test plots at Santiam proved to be 100 per cent *Aedes communis.* The water temperature was 62° F. at the time of treatment. Larvae from the plots near Diamond Lake were identified as follows: *A. communis* 35 per cent, *A. fitchii* (F. and Y.) 25 per cent, *A. increpitus* Dyar 25 per cent, and *A. cinerus* Meig. 15 per cent. The water temperature was 44° F.

A summary of all the field tests is given in Table 1. Only the 24-hour mortality counts are shown. The 48-hour readings could not be obtained in all cases, but the mortality was, of course, greater than for the 24-hour counts. The oil treatments at 0.01 pound of DDT per acre and the dust treatments at 0.1 pound per acre gave more than 90 per cent mortality, and the oil at 0.05 pound gave 99 per cent.

Laboratory Tests.—A series of laboratory tests with various insecticides were made on fourth-instar mosquito larvae collected in mountain areas. Identification of the several lots used showed 93 per cent *Aedes communis,* 6 per cent *A. hexodontus,* and 1 per cent *Aedes* sp. Acetone solutions of DDT and some of the newer chemicals—gamma-benzene hexachloride, chlorinated camphene, chlordane, and the methoxy analog of DDT—were used in beakers containing the larvae in 600 ml. of water. The temperature ranged from 50° to 60° F. in the various tests.

DDT at 1 part in 600 million parts of water killed about 85 per cent of the larvae in 48 hours (Table 2). Previous tests had shown that one-half this concentration was required to give 90 per cent mortality of *Aedes vexans* (Meig.), and *A. sticticus* (Meig.). DDT and gamma-benzene hexachloride were about equally toxic to mountain species and chlorinated camphene, chlordane, and the methoxy analog of DDT were somewhat less effective.

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OBSERVATIONS ON MOSQUITOES AND MALARIA CONTROL IN THE CARIBBEAN AREA. PART III—TRINIDAD

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After leaving British Guiana in April 1946, the senior author stopped over for a few days on Trinidad, where two difficult and totally different problems of anopheline control were being studied. This work has been carried on for several years, as a result of malaria surveys of the Crown Colony of Trinidad and Tobago that were organized in 1941 by Dr. W. G. Downs. Later the work was placed under the direction of R. C. Shannon, and in 1943 a Malaria Division of the Government was formed, which continues to function with the junior author as the medical officer in charge.

Anophelines of Trinidad and Tobago

Fifteen species of anophelines have been found in the Colony and have been fully reported on in the Malaria Survey of Trinidad. Of these species, only five (numbered in list that follows) are commonly encountered. *Anopheles pseudopunctipennis* Theob., which has previously been reported on the island, has not been found. *A. pessoai* G. and L., *A. punctimacula* D. and K., *A. intermedius* Chagas, *A. homunculus* Komp, *A. anoplus* Komp, and *A. (Kerteszia)* sp. are new species not previously reported in Trinidad.

A. aquasalis Curry (1). The most important vector of malaria; breeds in brackish water, in coastal swamps, and in river mouths, but is also found in fresh-water streams, ponds, and dams.

A. oswaldoi Perry (2). Associated with *A. aquasalis* in fresh-water collections; a zoophilic species.

A. albitarsis (3) L.Arr. Breeds in rice fields, ponds, and drains; sometimes associated with *A. aquasalis*. This species is suspected of being a minor vector.

A. pessoai. A rare species; taken in collections at Piarco, Valencia, and Moruga. May have been brought to the colony by aircraft.

A. neomaculipalpus (4) Curry. Found in savannah pools, rice fields, and other small and temporary main pools. This species is suspected of being a minor vector.

A. apicimacula D. and K., *A. punctimacula, A. intermedius,* and *A. mediopunctatus* Theob. These are rare mosquitoes found breeding in pools and streams in forest country.

A. eiseni Coq. A rare forest mosquito found in streams and pools.

A. nimbus Theob. A rare forest mosquito.

A. bellator D. and K.(5) An important vector of malaria; breeds in bromeliads, especially the large tank species (e.g., *Gravisia* spp.), growing on immortelle trees partly exposed to sunlight. This mosquito is important only in the heavy rainfall zones (over 90 inches of rain) of Trinidad where the plants hold enough water to support breeding the year round, and so maintain high mosquito densities.

A. homunculus. This is a bromeliad-breeding anopheline and is found associated with *A. bellator*. It prefers, however, to breed in the smaller plants and in positions of greater humidity and less exposure to sunlgiht.

A. anoplus and *A. (Kerteszia)* sp. These two species were found among material of *A. homunculus* collected in the Valencia area of north Trinidad, and were identified by dissection of the male terminalia.

Of these anophelines only two, *aquasalis* and *bellator,* are important vectors of malaria. The areas of high malaria incidence in Trinidad are therefore found wherever these two species are abundant—that is, along coastal areas and in the heavy rainfall zones. Spleen rates as high as 80 per cent have been found in both areas. In other parts of the island malaria rates are generally low.

The *Anopheles aquasalis* Problem

Two or three miles southeast of Port-of-Spain lie two large salt marshes, the Laventille and Caroni swamps. Several hundred acres of black, white, and red

[1] Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture.

[2] In charge, Malaria Division, Trinidad Government—Rockefeller Foundation.

mangrove cover the area, and *Anopheles aquasalis* breeds there in abundance during the greater part of each year. This anopheline is strongly zoophilic. Tens of thousands of this species may be seen nightly in a stable near the marshes where about 100 water buffaloes are quartered. The density of this species appears to be great enough to maintain a high malaria incidence in the surrounding villages.

Apparently *aquasalis* is a reasonably strong flier, because an epidemic of malaria soon broke out in a newly constructed village extending from 1 to 3 miles from the edge of the Laventille swamp. From a casual inspection of the village site one would discount the possibility of a malaria hazard. The village is at least 1 mile from the border of *aquasalis* breeding areas, and beyond a ridge several hundred feet above sea level with topography that permits excellent drainage. The development and use of a so-called dawn trap, however, proved that *aquasalis* was abundant.

The dawn trap was constructed by R. C. Shannon to take advantage of two of the dominant tendencies of this anopheline, namely to enter houses and stables at night for blood and to leave them at dawn. With this trap information has been obtained to prove that *aquasalis* has migrated inland over rough country as far as 5 miles from its salt-marsh breeding grounds. Twelve of these traps have been used in this village during the last 4 years (1943–1946), with an average yearly capture of more than half a million *aquasalis* mosquitoes.

The spring cleaning operations of clearing, draining, grading, and oiling are often used against *aquasalis* and give excellent results in several small isolated areas where more permanent measures would be uneconomic. In more populated areas, particularly where *aquasalis* is found to be breeding largely in the blocked mouths of small streams, a special low-tide culvert with a seahead [3] is used with great success. Automatic siphon-flush arrangements have also proved useful, especially on some of the small streams.

There are several thickly populated areas in the colony that are located close to large swamps where it is not possible to carry out permanent antimalarial measures owing to limited resources. In these areas residual spraying with DDT has been successful, and more than 20,000 houses have been so treated.

THE *Anopheles bellator* PROBLEM

One of the most intriguing malaria problems in the world may be found in the cacao estates in the wetter portions of Trinidad. Throughout great sections forests have been replaced by plantations of cacao. Here the cacao tree is protected by tall, regularly interplanted shade trees, the immortelles *(Erythrina glauca* and *E. micropteryx)*. A large human population obtains its livelihood within or near these artificial forests. Thus the cacao industry is responsible for the contact between man and the malaria vector.

A considerable flora of sun epiphytes grows on the immortelle trees. In fact every tree supports these air plants. There are many species, but the bromeliads are the most numerous. Not all of these plants are hosts to *Anopheles bellator,* but one of the most common large ones, *Gravisia aquilega* L. (Fig. 1), is by far

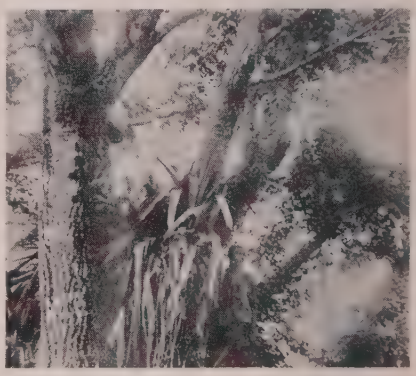

FIG. 1. *Gravisia aquilega,* host plant of *Anopheles bellator,* in an immortelle tree.

[3] Designed by C. E. Newbold, a former antimalaria engineer.

its most important host plant. Rarely can one find a plant of this species in which *bellator* larvae are absent. Another common large bromeliad is *Aechmea nudicaulis,* but in this species *bellator* is seldom, if ever, found. Inaccessibility of the water surface may exclude *bellator* from this bromeliad. These plants have high, narrow, tubular rosettes of leaves, which are stiffly erect above the interfoliar water.

The peculiar breeding habit of *bellator* precludes any practical attempt to control it with DDT residual sprays. This species is rarely seen within dwellings. It is, however, active throughout the day, and freely attacks laborers in the shade of the cacao trees on damp days. These mosquitoes also bite people resting on their verandas in the evening.

It has not been found practicable to destroy these bromeliads by hand, because the cost is prohibitive. Furthermore, few laborers can be found who are willing to climb these trees. The immortelle trees are high, and the limbs are brittle and break easily. They are also covered with large thorns, and because of the luxuriant growth of epiphytes they usually support large numbers of ants, scorpions, spiders, and snakes, which have caused serious accidents.

The difference between the bromeliad leaves and the leaves of the cacao and immortelle has made it possible to use several chemical sprays as bromelicides. A 0.5 per cent solution of copper sulfate has given the best results, although lead arsenate at a concentration of 0.1 per cent is also effective.

The spraying equipment developed by the U. S. Bureau of Entomology and Plant Quarantine (Fig. 2) is the most satisfactory device tried for applying these sprays. Sufficient power is developed by the pumping unit so that it can be left outside the area to be treated and connected with hose lines extending into the plantation for several hundred feet.

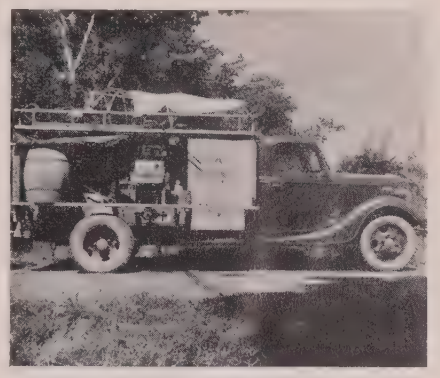

Fig. 2. Equipment used in applying copper sulfate sprays to destroy bromeliads.

Here again is an example of man-made malaria. Plans are now under way to abandon the interplanted immortelle shade trees and protect the cacao trees with windbreaks. Such a change, which is now being encouraged by the Government, would soon remove the bromeliad-*Anopheles bellator* complex, and consequently endemic bromeliad malaria should disappear from Trinidad.

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ASSOCIATION NEWS

ANNUAL MEETING OF THE AMERICAN MOSQUITO ASSOCIATION, HELD AT PHILADELPHIA, PA., ON APRIL 5, 1947

SUMMARY OF THE PROCEEDINGS

The meeting was opened at 9:45 A.M. by the President, Mr. H. H. Stage, Bureau of Entomology and Plant Quarantine, Washington, D. C.

The chairman of the Committee on Arrangements, Mr. Roland E. Dorer, State Director of Malaria Control, Norfolk, Va., was called upon to explain the general rules to be followed by each speaker. All discussion was extemporaneous.

The president called upon various members in turn to introduce themselves, briefly to describe their work, and then to answer questions relating to subjects of special interest. In order to conserve space, only the answers to the questions are printed, and most of them have been condensed or paraphrased.

DR. F. C. BISHOPP, in charge of research for the Bureau of Entomology and Plant Quarantine, gave a brief outline of his duties, and described the organization of the Bureau and the services performed by its several Divisions. He pointed out that while the Division of Insect Identification and the Insecticide Division are obviously of special interest to mosquito control workers, the Division of Foreign Parasite Introduction, which, among other duties, adapts research findings to special uses, and the divisions set up on the basis of crops, also contribute much information which can be used in the field of insects affecting man and animals.

MR. CHESTER ROBINSON, Manager of the East Side Mosquito Abatement District of California, stated that the principal mosquito problem in his district is *Aedes dorsalis* and *Anopheles quadrimaculatus* breeding in the irrigated orchards and the permanent pasture areas. In some irrigation districts drainage has already been provided; other districts only reserve the right for ditches. The present districts of California have been doing quite a bit of drainage work, both deep-well pumping to lower the water table, and surface drainage pumping in reclaiming water for reuse.

Funds for the district come from two sources: 1. A special tax levied against all property within the district, which shall not exceed fifty cents on each $100 of assessed valuation; and 2. a special grant from a State appropriation of $600,000 made to the State Board of Health, to be used for the purpose of getting new pest abatement districts started. A bill now before the State Legislature is designed to repeat this appropriation for another year.

MR. W. E. BICKLEY, University of Richmond, teacher of entomology and zoology, mentioned that the several control districts in Virginia are all under the direction of Mr. Dorer as a representative of the State Department of Health. The State Department of Health partially finances the work and provides an amount of money in proportion to the amount provided by the locality or district. Each commission is made up of two or three citizens, and the State Commissioner of Health is ex-officio a member of each district commission.

DR. L. DAUTREBANDE, pharmacologist and entomologist, in charge of general organization for the District of Katanga in the Belgian Congo, stated that all of the natives are malarial, with *Anopheles gambiae* as a vector. Other mosquito-borne diseases in the territory are filariasis and sleeping sickness. With the tsetse fly, very good control was obtained with DDT in the straw huts, using DDT aerosols the droplet diameters of which ranged from one to five microns. Most

of the aerosols are of water suspensions, produced under high pressure and filtered through liquid. With a very large organization it might be possible to eradicate *Anopheles gambiae* from that part of the world with a DDT residual spray. The economic resources of this particular region are timber and minerals.

Mr. La Dow, of Gloucester County, New Jersey, stated that *Anopheles quadrimaculatus* is the most prevalent anopheline in his section. On the marshes, where ordinary measures were insufficient, DDT was tried as a barrier ground spray for *vexans*. Wettable DDT was applied at 35-pound pressure, both from pumps on trucks, and from the air, to create a barrier zone about 50 to 100 feet wide around the marshes, spraying both ground and vegetation. A 95 per cent control outside the marsh was obtained by applying one pound DDT per acre over the barrier zone. There was a fine demonstration of mosquito control in industrial plants which were completely surrounded by marshes. A 24-hour operating schedule required many employees to wear head nets and gloves during periods of peak mosquito activity. As many as 250 female mosquitoes per night were caught in a trap adjacent to those properties; but in a demonstration area around some warehouses, no mosquitoes were taken in a trap for three weeks. The fourth week there were three.

There was no evidence that DDT killed birds or drove them away.

Dr. Bishopp, in answer to a question, said that the Food and Drug Administration and the National Institute of Health are doing extensive research on chronic toxicity of DDT and a number of other insecticides, but they are not fully prepared to give an answer about the general toxicity of DDT. It appears that when DDT is used in accordance with directions set up for its use, there is very little hazard in connection with mosquito control operations.

Mr. L. W. Smith, Superintendent in Middlesex County, and in the absence of Mr. Vanderworker, Acting Superintendent in Union County, New Jersey, described the Union County work. Union County is rather small in area, but has a considerable mosquito breeding area, and has a fairly large appropriation for this part of the country—$80,000. Middlesex County has important industrial sections, a few seashore resorts, and extensive farming areas. The appropriations there are about $26,000 to $27,000. One problem is to get a good, light, ditch-cleaning machine, and to develop something to take care of the "peak load." The airplane was considered unsatisfactory with its present equipment. When the plane went over dense stands of foxtail (*Phragmites*), records from mosquitoes hung at different heights from the ground showed that control under those conditions did not occur. There are probably 20,000 to 30,000 acres of this foxtail in the metropolitan area, and it is a big problem. Aerosol fog machines were not used on Union marsh, as they were in Bergen and Hudson.

Mr. Perry W. Ruth of Norfolk, Va., congratulated the president and other officers of the Association on the quality of their leadership during the past year. He then mentioned the formation of the Virginia Mosquito Control Association, of which he is the first President, and of which Mr. R. E. Dorer is Secretary and Treasurer.

Dr. Bishopp, at Mr. Stage's request, brought up the matter of holding the next annual meeting of the Association in conjunction with the International Congress on Tropical Medicine. The dates are May 5 to 10, 1948, in Washington, D. C. One of the twelve sessions will be on malaria, one on veterinary medicine, one on entomology, one on protozoology; and one general session on public health which will deal with administration, etc., covering that whole interesting field in which all members of the Association are concerned. There will also be some excursions in which the delegates will be permitted to visit the National Institute of Health, the Navy Research Institute at Walter Reed Hospital, and Beltsville Agricultural Re-

search Center where we are doing some work. It is also hoped to have large exhibits of ways of combating mosquitoes and malaria, including the various devices involved and the procedure being followed in this country. Members of the American Mosquito Control Association might play an important part in putting over some of that educaitonal work.

Regular members pay $10.00, which involves not only the privileges of attending the meeting, but also a copy of the proceedings, which is quite a sizable volume. The associate membership is $5.00. It is hoped that a good representation of engineers, doctors, entomologists, and members of other related groups may become active members and participate in voting and the general conduct of the Congress. Sustaining membership will involve a good fee on the part of industry and will permit members to have exhibits.

It was moved, seconded, and passed that the American Mosquito Control Association shall become one of the sponsors of the Congress, and that the chairman shall appoint a committee to cooperate with the general program committee of that group. Mr. Stage appointed the following committee: Dr. F. C. Bishopp, chairman; Harold Gray from California, R. E. Dorer from Virginia, W. V. King from Orlando, Fla., and Don M. Rees from Utah.

The Resolutions Committee, through Mr. Vannote, its secretary, presented a resolution to the effect that the Association, which represents Mosquito Abatement Districts or commissions in 37 States or Territories, urge the War Assets Administration to take steps to release immediately surplus materials and equipment for purchase by mosquito control and mosquito abatement agencies and public health agencies.

The resolution was accepted.

MR. STAGE showed a series of Kodachrome slides illustrating his trip to South America. Among the mosquito control observations that he mentioned in his accompanying remarks was the fact that oil solutions of DDT applied to adobe walls are practically worthless, but that with an emulsion, only one treatment a year was needed. He thought, further, that the water suspension was even more effective. In Maracaibo, the Rockefeller Foundation is testing several hundred kinds of DDT formulations on several dozen different kinds of surfaces, using boxes lined with these surfaces.

MR. H. F. GRAY, of California, spoke briefly to call attention to a paper by Ted Raley describing what he called a "plumber's nightmare," an aerosol generator made of pipe fittings, which can be attached to the exhaust of trucks and jeeps.

(Editor's note: The paper mentioned was published in the June, 1947, number of MOSQUITO NEWS.)

MR. H. D. PETERS, Director of Sanitation, City Health Department, Jacksonville, Fla., stated that his mosquito control group is financed through a budgetary item, entirely by the City of Jacksonville. Recently the State Budget Committee recommended a bi-ennial fund for use by the State Board of Health to promote the establishment of additional mosquito control districts. The law states that it is permissible for any area to vote a district and to levy taxes; but none of this recommended special fund is to be spent until a survey is made, and the district approved by the State Board of Health. Prior to the appropriation of such a fund, the State Board had no facilities or finances to make such a survey. One district was established almost a year before they could do any work.

MR. A. CARL HAAG, MR. W. D. HENDERSON, and others spoke of the mosquito problems in Ocean County, New Jersey. The principal problem is 35,000 acres, mostly salt marsh, of mosquito breeding area. Ocean County has reduced breeding by 90 per cent. There are some cases in Ocean County where ditching won't take care of "peak loads." The water seeps or trickles through the grass in these low areas, and the fish can't get in to do the job. It seems to be a problem of larvicid-

ing, and a high concentration larvicide is needed.

DR. B. V. TRAVIS, U. S. Bureau of Entomology and Plant Quarantine, mentioned that while mosquito ovicides appeared, in general, not too effective, preflooding and prehatching treatments show very great promise. How generally applicable they will be where acreage runs into thousands, remains to be seen, but preliminary results seem encouraging. It would seem that the prehatching treatment, if it proves to be feasible, offers more promise of controlling mosquitoes regardless of weather conditions than does the attempt to control the adults directly, although weather conditions may prevent control through larvicides also. Applications from the ground are probably not affected by weather conditions as much as applications from the air, either for adult, or for larva control; but in a breeding area aggregating hundreds of thousands of acres, ground treatment in terms of temporary control is not practicable. There are many places where permanent control measures are not feasible or possible. For one area, prehatching treatment may completely solve the problem; for another area, it may have to be a larvicide or an adult control.

MR. WHITE, supervisor of the East Volusia County (Florida) Mosquito District, commented very favorably on prehatching treatments. With ten pounds of 10 per cent DDT to the acre, excellent results were obtained.

MR. H. A. CRANDALL, Superintendent of the Toledo Area Sanitary District, Toledo, Ohio, stated that the district includes an area of a little more than 150 square miles in and around Toledo. It lies at the western tip of Lake Erie at the junction of the lake with the Maumee River. The region is very flat and thus drainage is extremely poor. Principal mosquito problems are the woodland breeders and the flood water breeders in the spring and during the summer. Probably the most difficult mosquito problem is *Mansonia* breeding in the district's extensive cattail marshes, of which there are over 700 acres. This coming year will be the district's first year of control operations. Funds for the district are obtained by a special tax assessment for the property within the district.

MR. STAGE (Bureau of Entomology and Plant Quarantine) described the research done in the several laboratories which are working on insects affecting man and animals. In one of the projects, in collaboration with the Army at Fort Sam Houston, it is hoped to test the efficacy of DDT in control of ticks over an area of about 2,000 acres.

After Mr. Stage's remarks, a vote of thanks was extended to Mr. Dorer for his work in planning the meeting, and adjournment followed.

LETTER TO THE EDITOR

Editor, Mosquito News:

At the recent Executive Committee Meeting of the Association, President Duke Peters presented me with a bound volume containing letters sent me by members from all over the United States, from France, from South America, and from Mexico. This fine tribute of your cordial good wishes is sincerely appreciated. I trust that I may continue to serve the Association for many years to come. It is a real pleasure for me to do so. Thank you all.

HARRY H. STAGE

ELECTION OF OFFICERS AND APPOINTMENT OF COMMITTEES

Results of the 1947 election of officers and notice of the following committee appointments came to the editor too late to be announced in the September number of MOSQUITO NEWS, because of unavoidable delays due to complications in the conduct of a mail ballot for the 1947 election of officers.

ELECTION OF OFFICERS FOR 1947–'48

President.....H. Duke Peters, Fla.
First Vice President.....Harold F. Gray, Cal.
Second Vice President....Willard V. King, Fla.
Executive Committee Member at large
T. E. McNeel, La.
Executive Committee Member at large
Don M. Rees, Utah
Editor, MOSQUITO NEWS
Robert D. Glasgow, N. Y.
Publications Committee member at large
Archie D. Hess, Ala.
Publications Committee member at large
Bernard V. Travis, Wash., D. C.
Business Manager, MOSQUITO NEWS
C. T. Williamson, N. Y.
Secretary-Treasurer...Thomas D. Mulhern, N. J.

COMMITTEE APPOINTMENTS FOR 1947–'48

(The President and Secretary-Treasurer are ex-officio members of standing committees.)

COMMITTEE ON MEMBERSHIP

Archie D. Hess, Chairman, Alabama
T. G. Raley, California
C. C. Deonier, Florida
Hernando Rey, Colombia, S. A.
John H. Huber, Portland, Oregon
Luis Vargas, Mexico
Helen Louise Trembley, Maryland

COMMITTEE ON NOMINATIONS
(All past Presidents)

H. H. Stage, Chairman, Washington, D. C.
Perry W. Ruth, Virginia
Robert L. Vannote, New Jersey

COMMITTEE ON LEGISLATION

Robert L. Vannote, Chairman, New Jersey
E. Chester Robinson, California
R. E. Dorer, Virginia
H. W. Van Hovenberg, Texas
Donald L. Collins, New York

COMMITTEE ON FINANCE

Lester W. Smith, Chairman, New Jersey
Robert D. Glasgow, New York
E. E. Lynch, Delaware

COMMITTEE ON AUDIT

Lester W. Smith, Chairman, New Jersey
E. J. Hansens, New Jersey
R. J. VanDerwerker, New Jersey

COMMITTEE ON CONSTITUTION AND BY-LAWS

Robert D. Glasgow, Chairman, New York
Bailey B. Pepper, New Jersey
Harold F. Gray, California
Don M. Rees, Utah
John A. Mulrennan, Florida

SPECIAL CONFERENCE ON THE USE OF AIRCRAFT IN MOSQUITO CONTROL WORK

In response to a call issued early in the year by the President of the Association, fifty members of the American Mosquito Control Association, including entomologists, sanitary engineers, physicians, pilots, and others interested in the subject, met at the Langren Hotel in Asheville, North Carolina on October 16th, 17th and 18th, 1947, for a conference on the latest developments in the rapidly growing use of aircraft in mosquito control work.

Represented at the Conference by interested officers, delegates and other personnel, were:

The Dominion of Canada
The U. S. Public Health Service
The U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine
The U. S. Fish and Wildlife Service
The U. S. Navy Air Corps
The U. S. Army Air Corps
The Medical Laboratories and Engineers' Office, 3rd Army
The Tennessee Valley Authority
The Rockefeller Foundation
New Jersey Agricultural Experiment Station
Mosquito Control Agencies in California, Florida, New Jersey, New York, Rhode Island, and Delaware
Various City and State Departments of Health
Also in attendance were:
Commercial Flight Service Pilots, and Industrial Entomologists

Under the able chairmanship of Past President Harry H. Stage, the conference first canvassed the general field; it then decided upon a logical subdivision of the subject matter into topics, each to form a chapter in the finished report; and finally assigned those in attendance, each to the subcommittee most appropriate to his special background of interest and experience, each subcommittee to formulate a preliminary draft for the final report of the conference. After repeated general conferences to discuss and coordinate sub-

committee reports, this preliminary draft was then placed in the hands of a special editorial committee of which Dr. P. F. Russell of the Rockefeller Foundation is Chairman, for final revision.

The results of the conference will be published in the same format as that of MOSQUITO NEWS in order that, if desired, it may be bound in the corresponding volume at a supplement.

The report of the conference will be well illustrated, and will include chapters on Types of Aircraft; Types of Adaptive Equipment; Operational Procedure; Appropriate Insecticides and Formulations; Appraisal of Results; Precautions to be Observed; Legislative and Legal Considerations; and a Selected Bibliography.

An appendix will give tables of solvents for DDT and other insecticides; military specifications for DDT and other insecticides, solvents, carrying agents, dispersants, and the like; and will contain diagrams for insecticide dispersing equipment for use on small and large aircraft.

The report is designed to sell for $2.00 (gratis to those attending the Asheville conference). If income from sales and advertising is sufficient to permit doing so, a discount of $1.00 per copy will be given members in good standing. It is planned to have the report available before the Annual Meeting in March, 1948

Special credit should be noted for the excellent cooperation of the U. S. Naval personnel in Asheville, who provided for mimeographing reports of the several committees as they were prepared for reading back to the entire group for discussion and general coordination.

ANNOUNCEMENT OF ANNUAL MEETINGS

The Virginia Mosquito Control Association will hold its annual meeting in Norfolk on Friday, January 16, 1948. Place: Monroe Room, Monticello Hotel.

The California Mosquito Control Association will hold its sixteenth annual Conference at Agricultural Hall, University of California, Berkeley, on February 12, 13, and 14, 1948.

The Florida Mosquito Control Association will hold its annual meeting in late March, in conjunction with the annual meeting of the *American Mosquito Control Association*. Place, Fort Pierce, Florida. Date, March 28, 29, 30, and 31, 1948. Inspection tour to follow if enough AMCA members are interested.

The American Mosquito Control Association has accepted the invitation of the *Florida Mosquito Control Association* to hold its 1948 annual meeting jointly with the *Florida Association* in late March. Place, Fort Pierce, Florida. Date, March 28, 29, 30, and 31, 1948.

A Special Conference on Ground Equipment Used in Mosquito Control Work will be made the central theme of the joint annual meetings of the *American Mosquito Control Association* and the *Florida Mosquito Control Association*. Place, Fort Pierce, Florida. Date, March 28, 29, 30, and 31, 1948 (see announcements above). A report of this conference, to parallel that of the Asheville conference on the use of aircraft in mosquito control work, will be published by the AMCA.

The New Jersey Mosquito Extermination Association will hold its 35th (1948) annual meeting on April 13, 14, 15, and 16, at Hotel Haddon Hall in Atlantic City. An important feature of this meeting will be indoor exhibits, and an outdoor demonstration of mechanical equipment used in mosquito control work.

NEWS AND NOTES

CALIFORNIA SUGGESTS COOPERATIVE PURCHASE OF DDT. Does your agency wish to jointly purchase DDT? In view of the saving to mosquito abatement districts and other mosquito control agencies which would result from the purchase of DDT and other insecticides in mass volume, the California Mosquito Control Association is proposing that such action be taken. Several mosquito abatement districts have begun to dicker with chemical companies for reduced price on carload delivery of DDT, but it is probable that a much lower price on mosquitocides to the individual agency could be obtained if collective purchase were made by all of the mosquito control agencies in California.

It is suggested that each mosquito control agency supply the California Mosquito Control Association with an estimate of its DDT and other mosquitocide needs for the calendar year 1948, stating exact type of material and quantity desired and preference for size of container, type of emulsifier if desired, type of solvent desired, etc.

On the basis of the aggregate needs of the mosquito control agencies in California, chemical companies will be contacted and requested to supply bids with the understanding that the low bidder would be expected to assume the bookkeeping requirements in delivering the amount and type of DDT or other chemicals desired by the individual agency, in accordance with each agency's wish.

The price to be expected depends, of course, upon the number of agencies participating and the volume of the order. It is estimated that if a large share of the control agencies cooperate, the prices of the various materials should be considerably reduced over present quotations.

It is anticipated that an order could be placed some time in early November and that delivery would be expected early in 1948. This would conveniently find districts flush from receipts of monies due to the first collection of taxes. If your agency desires to participate please submit a tentative itemized request or order to the California Mosquito Control Association, 2180 Milvia Street, Berkeley, California, by October 15, 1947. Your request or order will be accepted as an intention to purchase and the amount and type of materials will be transmitted to the chemical company supplying the low bid as part of the total order.

This action is being taken in response to the requests of a great number of the mosquito abatement districts for their economy.

MOSQUITO BUZZ

(Have other regional Mosquito Control Associations likewise considered cooperative buying?—*Editor's Note.*)

COLONEL WILLARD V. KING, CITED FOR LEGION OF MERIT, performed exceptionally meritorious services in the Southwest Pacific Area, from February 6, 1943, to July 1, 1945. He demonstrated notable qualities of professional knowledge and leadership in directing the initial Malaria Survey Units assigned to New Guinea. As Commanding Officer of the 4th Malaria Survey Unit, 3d Medical Laboratory, Colonel King resourcefully prepared and executed plans for conducting comprehensive mosquito surveys, rendering outstanding service in reducing a malarial rate which was causing widespread hospitalization among combat elements. Despite hospitalization for serious illness, he refused evacuation, remaining to serve with great distinction as Theater Entomological Consultant, accumulating information of vital consequence concerning more than 100 species of mosquitoes, of which many were new to science.

SERVICES OF ENTOMOLOGIST REQUIRED. BUREAU OF VECTOR CONTROL (CALIFORNIA STATE DEPARTMENT OF HEALTH) SUGGESTS ENTOMOLOGIST DUTIES. In a memorandum to all mosquito control agencies participating in the mosquito vector control subvention program, the Bureau of Vector Control outlined the functions which an entomologist might provide any agency. In general they are:

1. Accurate appraisal of the existing and potential mosquito sources within and adjacent to the district, with such information systematically recorded on appropriate maps and records.
2. Evaluation of adequacy and efficiency of control program.
3. Training of organization personnel.
4. Testing of control methods, materials and techniques, to determine their reliability in obtaining control, and the degree of control.
5. Assist in planning, preparing and carrying out public relations and educational programs, which in the long run serve to document the district's activities by recording its history.
6. Immediate application of new methods, materials and techniques developed by contemporary entomological, chemical, medical and veterinary workers.
7. Investigation of encephalitis, encephalomyelitis and malaria cases, including epidemiological analyses of their occurrence.
8. Assist in district administration, particularly in decentralized districts.

All mosquito control agencies participating in the State subvention program are required to include the services of an entomologist as a part of the technical guidance of the mosquito vector control activities, the amount of service to depend upon the needs of the agency.

MOSQUITO BUZZ

EASTSIDE AND TURLOCK (CALIFORNIA) MADS' CONSIDERING FLY CONTROL. Inasmuch as DDT residual operations for mosquito control in the Eastside and Turlock MADS' have incidentally accomplished such drastic reduction in the fly population of the two districts, both are seriously considering undertaking the control of flies in addition to mosquito control as a district function. Tentative estimates indicate that fly control could be obtained by increasing the tax approximately 3¢ to 5¢ per $100.00 assessed valuation.

MOSQUITO BUZZ

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EDITORIAL SECTION

SHOULD THE AMERICAN MOSQUITO CONTROL ASSOCIATION BE REORGANIZED?

The rapid growth of the American Mosquito Control Association has now reached a point where it is timely to ask whether its present form of organization should not be changed.

Having started in 1936 as the Eastern Association of Mosquito Control Workers, which in 1941 began publication of MOSQUITO NEWS, this Eastern Association grew rapidly until by January, 1944, it had come to include members from 32 of the United States of America and 9 foreign countries. No longer a truly Eastern Association, at the next annual meeting, March 15, 1944, it was voted that the name should be changed to the present American Mosquito Control Association.

At this time little change was made in the old constitution, which provides for a type of organization better suited to a limited area where all of the members can assemble for the transaction of Association business, rather than to a continental area where only a fraction of the membership are likely to attend any particular meeting, and where actual member participation cannot be adequately provided for, no matter how meetings may be shifted from region to region within the larger area.

Further growth of the Association, the membership of which now comprises all or a substantial proportion of the members of the many local mosquito control commissions and even of several regional associations, would seem to make a different type of organization more appropriate to its present status.

For this reason, the question has been raised whether a federal, or republican, or representative type of organization might not be more in order. Various other national societies and associations have found one or another form of this general type of organization well suited to their needs.

Several possibilities have been mentioned. Final power, of course, would be vested in the membership for all matters of fundamental importance. But with the area covered by the Association divided into six or seven regional areas, each with a Regional Director who would be a Regional Vice President of the National Association, this small group of Regional Vice Presidents, together with the National President, the First and Second Vice Presidents, and the Treasurer, might constitute a representative policy-making National Council; and this National Council, together with the chairmen of the ten or twelve standing committees, might constitute the Board of Directors. If each standing committee might then include a member from each regional area, this should afford ample provision for the orderly flow of information, action, responsibility, and authority between the general membership and the National Council.

Standing committees might be something like the following:

1. Committee on Current Information Relating to Mosquito, and Other Arthropod-Associated Health Hazards.
2. Committee on Current Information Relating to Malaria Control, Including Other Arthropod-Borne Diseases.
3. Committee on Current Information Relating to Vector Control, Including Related Pest Species.
4. Committee on Current Information Relating to Other Pests Controllable Only by Community Action.
5. Committee on Finance, Including Endowment Fund.
6. Committee on Administration of Industrial Research Fellowships.
7. Committee on Legislation.

8. Committee on Public Information.
9. Committee on Relations with Other Technical, Scientific, Educational, and Public Service Agencies.
10. Committee on Publications.
11. Committee on Membership.
12. Committee on Sale of Advertising Space in MOSQUITO NEWS, or in Such Other Publications as Might Be Undertaken.

A small National Council would permit more frequent meetings for consideration of special problems as they may arise, perhaps with some provision for equalization of travel costs. At least two such meetings should be held each year. An annual convention, preferably with at least one day devoted to a paper-reading session, would be attended by voting delegates or proxies from individual commissions and the like. The number of such voting delegates could be allocated on some representative per capita basis.

Regional conferences, inspection trips, and the like would be encouraged; and Regional Directors would be responsible for looking after and promoting the interests and activities of the Association in their respective areas.

Members of the National Council might be elected for two-year terms, possibly with one re-election permitted, and with terms staggered to provide for continuity of policy.

An executive staff might be provided to look after routine affairs of the Association, perhaps comprising an Executive Secretary, a Comptroller, and an Editor of MOSQUITO NEWS. Officers of the Executive Staff, while presented for re-election periodically, would usually be retained as long as they might be willing to serve, or as long as their services were acceptable. While all officers now serve on an unpaid, volunteer basis, it is hoped that the Association may eventually be able to maintain a National Headquarters with a paid Executive Secretary and staff; and that these and other officers of the Association required to travel, may be given a travel allotment.

Provision might also be made for special-interest sections, such as Medical, Engineering, Entomological, Public Health, and the like, which might be represented on the National Council.

Appropriate officers will probably meet in the near future to consider Association problems; and at the same time may consider this, and other measures which might be in the best interests of the Association. Ideas and suggestions from interested members addressed to the Secretary will be welcome.

REVIEWS AND ABSTRACTS

THE INACTIVATION OF DDT USED IN ANOPHELINE MOSQUITO LARVICIDES. By W. M. Upholt (U. S. P. H. S., Communicable Disease Center, Technical Development Division, Savannah, Ga.). Public Health Reports 62(9):302–309, 1 fig. 1947. (Abstract.)

In contrast to DDT used as a wall spray or as a larvicide for *Aedes aegypti* (L.), DDT used as an anopheline larvicide in dosages that are effective but reasonably safe to other aquatic life show little or no residual toxicity. Several factors may contribute to this. The two most important appear to be redistribution of the DDT due to wind and wave action, and precipitation of suspended DDT followed by adsorption of the DDT by some part of the bottom-mud complex. Adsorption is relatively slow on mud and appears to be on the organic components of the mud only, sandy soils with a minimum of organic material being rather poor adsorbents.—Author's Abstract.

THE COMPARATIVE RESIDUAL TOXICITY OF DDT TO *Anopheles quadrimaculatus* WHEN APPLIED ON DIFFERENT SURFACES. By J. M. Clapp, R. W. Fay, and S. W. Simmons (U. S. P. H. S., Communicable Disease Center, Technical Development Division, Savannah, Ga.). Public Health Reports 62(5):158–170. 1947. (Abstract.)

The comparative residual toxicity of DDT sprayed on different materials, the effects of the spray application on different surfaces, and the effect of surface on the final residue distribution were investigated. Test panels of 17 types of surfaces including fabrics, paints, varnishes, wallpaper, whitewash, plastics, linoleum, and mud were prepared to duplicate field conditions as accurately as possible. These panels fitted into a wooden framework to form an exposure chamber in which insectary-reared adult female *Anopheles quadrimaculatus* mosquitoes were exposed for 60 minutes to 200 mg. DDT per sq. ft. residues. A 5 per cent DDT-xylene emulsion and a pine plywood surface, adopted as comparison standards, gave the following 48 hr. mortalities: 1 month—95 per cent, 2 months—90 per cent, 3 months—70 per cent, and 6 months—60 per cent. Results from other surfaces compared to the standard were: equal for fabrics and wallpaper, ½ to ¾ as good for varnishes, paints, fiberboard, and plastics, less than ½ as good for whitewash, fresh paints, linoleum and mud. Mud showed poor results even with 600 mg. DDT per sq. ft. Surface discoloration was not encountered except on over-application to blue wallpaper and dark gloss enamels. Kerosene substituted for xylene as the DDT solvent was a remedy for this discoloration. Experiments demonstrated that some DDT was lost below the surface from spray penetration on absorbent materials. Salt (NaCl) incorporated in whitewash increased the residual toxicity of subsequent DDT applications. Exposure to grease deposits lowered the toxicity of DDT residues.—R. W. FAY.

THE TECHNIQUES OF APPLICATION, AND THE CONTROL OF ROACHES AND BEDBUGS WITH DDT. By Robert L. Stenburg (U. S. P. H. S., Communicable Disease Center, Technical Development Division, Savannah, Ga.). Public Health Reports. (Abstract.)

Investigations were made using DDT for the control of the German roach, *Blattella germanica* (Linn.), the American roach, *Periplaneta americana* (Linn.), and the bedbug, *Cimex lectularius* (Linn.). Trapping methods for sampling roach infestations were unsatisfactory and populations were divided by premise inspections into 4 classes: (A) No roaches evident; (B) 1–5 roaches per room in evidence; (C) 6–50 roaches per room in evidence; (D) Roaches too numerous to count. Combinations of DDT-xylene emulsion sprays and DDT-pyrophyllite dusts were used in 5 general type treatments: (1) Over-all application with 2½ per cent DDT spray, (2) over-all application with 5- and 10 per cent DDT spray, (3) 10 per cent DDT dust to obvious resting places, (4) combined use of 5 per cent DDT spray and 10 per cent DDT dust, and (5) multiple DDT spray applications. Private homes, food stores, restaurants, hotels, and hospitals were treated and details of each type treatment are given. Methods (1), (2) and (3) gave good initial mortality but later were not entirely satisfactory. Method (4) reduced class D infestations to class A or B within 1 week and to class A within 4 weeks. Method (5) gave good results but required more work.

DDT toxicity to bedbugs was tested by applications of various solvent sprays containing 2½ to 35 per cent DDT to (1) mattress only, (2) mattress and springs only, (3) entire bedstead, (4) bedstead and adjacent walls, (5) walls and ceiling of room and all furnishings. All methods gave complete control of bedbugs during the 4 month study.—R. W. FAY.

A NEW TECHNIQUE FOR SAMPLING THE DENSITY OF HOUSEFLY POPULATIONS. By H. I. Scudder (U. S. Public Health Service, Savannah, Ga.). Public Health Rpts. 62, 4 figs. 1947. (Abstract.)

Previous methods of sampling such mobile insects as houseflies *(Musca domestica)* have been unsatisfactory. A new technique is suggested involving the use of a "fly grill" which consists of narrow strips of wood tacked together to form an open structure with a great length of exposed edges. Flies are found to rest freely on such a surface. When placed conveniently to centers of congregation the numbers of flies resting thereon

provide a reliable index to the relative number of flies in the congregation. An empirically justified index based on the average size of a constant number of the highest counts has been used as a guide for timing fly control activities in both individual establishments and in city-wide campaigns. It can also be adapted for use with blow flies (Calliphoridae).—W. M. Upholt.

Preliminary Studies on the Control of Blow Flies with DDT. By W. C. Baker and L. G. Schwartz (U. S. P. H. S., Communicable Disease Center, Technical Development Division, Savannah, Ga.). Public Health Rpts. (Abstract.)

Preliminary tests were made with DDT for the control of blow flies (esp. *Cochliomyia* sp. and *Lucilia* sp.), at a fish market, an abattoir, a hide processing plant, and a seafood plant, using 5 per cent DDT-xylene-*Triton* X-100 emulsion applied at the rate of 200 and 300 mg. DDT per square foot. By means of the grill method of measuring the fluctuation in fly populations, the variation in the degree of control achieved was found to be dependent to a large extent upon the relationship between the night resting places of the flies and the extent to which such places were treated. When only the area about the daytime breeding places of the blow flies was treated, control was obtained for a 2 to 3 week period. When night resting places were treated in addition to the daytime feeding places, the control obtained was greater and lasted effectively for periods up to 3 months.—W. C. Baker.

Effects of DDT Mosquito Larviciding on Wildlife. Part 1. The Effects on Surface Organisms of the Routine Hand Application of DDT Larvicides for Mosquito Control. By Clarence M. Tarzwell (Technical Development Division, Communicable Disease Center, U. S. P. H. S.). Public Health Reports 62(15):525–554. 1947. (Abstract.)

Quantitative sampling of the surface forms and counts of dead organisms on the water surface 24 hours after treatment were the methods used in this study. Routine applications of DDT as a dust caused little apparent damage to the surface organisms as indicated by gross observations. Paired square-foot surface samples taken before and 48 hours after treatment indicated few significant changes due to treatment. The seasonal trend of the population of surface organisms was somewhat affected by routine treatments with dust at the rate of 0.1 pound of DDT per acre, but the changes were not as great as those caused by treatments with solutions of DDT in fuel oil. DDT-fuel oil solutions killed the large surface insects such as Dytiscidae, Gyrinidae, Hydrophilidae and Corixidae at concentrations as low as 0.025 pound of DDT per acre. However, the kills resulting from applications of 0.05 or 0.025 pound of DDT per acre were proportionately much less than those resulting from applications at the rate of 0.1 pound per acre. The seasonal effects of routine DDT treatments as indicated by a comparison of the population of surface organisms in the treated and check ponds were quite marked. There was an increase in the number of Oligochaeta, Nematoda, and Copepoda, and a decrease in the Chironomidae, Hemiptera, Coleoptera and Ephemeroptera. Insects as a group decreased in number in the treated ponds with the largest decrease occurring among the Chironomidae. The net results of these changes are difficult to evaluate, but it appears that there is some reduction in the available supply of fish food. Reductions noted to date, however, have not been sufficient to affect the breeding stock; and since treatment is in localized areas, it is probably not sufficient to limit seriously the fish population by restriction of the food supply.—Author's Abstract.

The Australasian Anophelines as Vectors of Malaria. By I. M. Mackerras. Med. Jour. Australia 1(1):1–8. Jan. 4, 1947.

Dr. I. M. Mackerras presents some of the data accumulated during and since the war concerning the Australasian malaria vectors. Studies on the "vector qualities" were carried out in so far as possible, an attempt being made to judge susceptibility to infection, abundance, association with man, avidity for human blood, and longevity.

Since all Australasian species were found to be apparently highly susceptible to malaria infection, that criterion is not a limiting one. Abundance, although a basic vector quality, must be weighed with the other factors because some species are very abundant yet not important transmitters, e.g., *Anopheles bancrofti* at Cairns and *A. longirostris* in parts of New Guinea. None of the Australasian anophelines are "domesticated" but *A. punctulatus punctulatus* and *A. p. farauti* show a tendency to concentrate near native villages in New Guinea, a habit not shown by other anopheline species, either there or on the mainland of Australia.

Avidity for human blood, based on precipitin tests, has been hard to evaluate because a true picture is not presented if specimens are collected from native huts, an unnatural resting place for Australasian species. Collections of recently engorged specimens from their natural resting places were desirable and significant, but often difficult to obtain. In evaluating the evidence, however, Dr. Mackerras concludes that *A. punctulatus punctulatus,* at least in the Milne Bay population, is strongly anthropophilic, *A. p. farauti* associates with man and his domestic animals but has no particular feeding preferences between them, and a few species strongly prefer other animals.

Nothing is known of survival rates and duration of life of Australasian anophelines in nature, so the author obtained longevity data from laboratory colonies maintained at Cairns. The percentage of 4 species studied surviving to 17 days

are as follows: *A. p. punctulatus,* 53 per cent; *A. annulipes,* 38 per cent; *A. p. farauti,* 23 per cent; and *A. amictus amictus,* 1 per cent.

Taking the above vector qualities into consideration, the Australasian anophelines are placed into the following groups:

Proven dangerous vectors: *Anopheles p. punctulatus* Don. and *A. p. farauti* Lav.

Potential vectors under locally favorable conditions: *A. annulipes* Walk., *A. bancrofti bancrofti* Giles, *A. subpictus* Grassi, *A. amictus hilli* W. and L., and *A. a. amictus* Edw.

Unknown, but at most locally significant: *A. meraukensis* Venh. and *A. novaguenensis* Venh.

The primary vectors of New Guinea and the islands are the races of *Anopheles punctulatus,* the vector of Northeastern Queensland is *Anopheles p. farauti,* and the presumptive vector of sporadic malaria in the South is *Anopheles annulipes.* The vectors of the Northern Territory, however, are still undetermined. No permanent change in the distribution and amount of malaria on the mainland of Australia is expected unless a new vector is introduced. The possibility of introduction of *A. punctulatus punctulatus* into the tropical parts of the mainland cannot be taken lightly.—ROY W. CHAMBERLAIN, The Johns Hopkins University, Baltimore, Md.

THE EXPERIMENTAL USE OF DDT SPRAYS AS MOSQUITO LARVICIDES. By E. H. Arnold, Frederick F. Ferguson, and William M. Upholt (Malaria Control in War Areas, U. S. Public Health Service). Public Health Rpts. Suppl. 186:66–79. 1945.

Studies to determine the usefulness of DDT when substituted in part for fuel oil in anopheline larviciding are reported. Applications were with hand equipment, both compressed air sprayers and knapsack sprayers, and results were checked by dipping for larvae before and after treatment. Several types of application were tried: (1) a tight emulsion of No. 2 fuel oil containing DDT and water; (2) a quick-breaking emulsion of the same type (referred to as surface application); (3) a suspension produced by dissolving the DDT in ethyl alcohol and then diluting with water; and (4) bottom applications obtained by dissolving the DDT in a heavier-than-water solvent. Solvents tested included pine oil, sulfonated pine oil, xylene, kerosene, and a gas condensate liquor, as well as No. 2 fuel oil. In the tight emulsion, *Triton* X-100 was used as emulsifier; and in the quick-breaking emulsions, *B1956* or *Artic Syntex A* was used as emulsifier. *Intracol* was used as a dispersing agent in the alcoholic suspensions.

The bottom application was impractical to apply, but all of the other types of applications resulted in good control of mosquito larvae when applied at the rate of 0.1 pound DDT per acre. No appreciable residual effects were noted at dosages that were not obviously harmful to wildlife. Laboratory evidence supported the field observation that the distribution of the DDT, and thus its toxic action, was limited to the distribution of the solvent.

Further laboratory investigations indicated that one important factor in the failure to obtain residual effectiveness in field application was the inactivation (without decomposition) of the DDT by some factor in the bottom-mud complex.

Limited dosage-mortality and time-mortality studies in the field indicated that good larval control could be obtained with dosages as low as 0.006 pound per acre with some types of application.—W. M. UPHOLT.

TECHNIQUES AND APPARATUS USED IN EXPERIMENTAL STUDIES ON DDT AS AN INSECTICIDE FOR MOSQUITOES. By S. W. Simmons and Staff (Malaria Control in War Areas, U. S. Public Health Service). Public Health Rpts. Suppl. 186:3–20. 1945.

Window traps can be used for the determination of the subsequent kill of mosquitoes leaving rooms treated with DDT. The greatest difficulty has been experienced in determining effective kills and in keeping the mortality in check cages at a minimum. Humidity, wind, and temperature are factors of outstanding importance in the well-being of mosquitoes held in cages. Mortality due to natural causes or to handling should be kept below 20 per cent. Experiments should be conducted in areas having large mosquito populations in order to secure significant catches in the window cages.

The wall-cage test is a biological method of determining the residual toxicity of treated walls. Insects placed in glass chambers were exposed to treated walls for specific time intervals and then held 48 hours for observation of mortality.

The wall-cage test has been used successfully with both house flies and mosquitoes and undoubtedly could be adapted for testing other insects. The accuracy of the results, particularly when testing mosquitoes, depends to a large extent on the careful handling of the specimens both during and after the test.

A rapid, uniform, accurate, and widely applicable laboratory technique has been devised for testing the effect on adult mosquitoes of spray residues on various surfaces. Panels having a total surface of 1 square foot are fitted into a wooden framework and adult mosquitoes are introduced into the exposure chamber formed by the panels. After known periods of time they are removed and held for 48 hours to determine mortality. Transfer of adult mosquitoes from chambers to cages is accomplished by air currents. Each complete test requires approximately 15 minutes and no injury to mosquitoes or spray residues is evident. Uniform comparable results have been attained in replicated tests and good correlation with field results has been obtained.

The techniques employed in the laboratory test-

ing of DDT as an anopheline larvicide are briefly described.—Author's summary.

The Experimental Use of DDT in the Control of the Yellow Fever Mosquito *Aedes aegypti* (L). By W. M. Upholt, T. B. Gaines, S. W. Simmons, and E. H. Arnold (Malaria Control in War Areas, U. S. Public Health Service). Public Health Rpts. Suppl. 186:90–96. 1945.

Field and laboratory tests showed that DDT was a very satisfactory larvicide for the control of *A. aegypti.* When applied in a variety of typical *A. aegypti* breeding places, it remained effective over a period of five to six months or more. Even water removed from containers that had been treated 5 months previously and left in the open was highly toxic to insectary-reared larvae. The results were the same in metal, glass, wood, or rubber containers even in the presence of rust. (Of course no large amount of mud was present.) In the laboratory, larvae were affected much more rapidly than larvae of *Anopheles quadrimaculatus* but required a longer time to succumb. DDT at 1 ppm did not appear to prevent oviposition nor did it appear to kill eggs, but all larvae hatching from eggs deposited on treated surfaces, succumbed soon after hatching (the eggs were not removed from the treated surface). Dosages of DDT below 4 ppm did not kill pupae.—W. M. Upholt.

The Development and Longevity of *Haemagogus* Mosquitoes Under Laboratory Conditions. By M. Bates. Ann. Ent. Soc. Am. 40(1): 1–12. 1947.

The author has given detailed experiments which were carried on to test the effect of food and larval temperature on mosquitoes, especially *Haemagogus spegazzinii.* Studies of culture media involved different types of infusions. Results with Brewer's yeast were consistent and this was adopted as standard medium, both for raising larvae and for stimulus of eggs.

The larval development required 26 days at 20° C., 18 days at 25° C., 15 days at room temperature, and 12.5 days at 30° C. Adults from larvae kept at lower temperatures were larger and hardier than those kept at higher temperatures. Twenty degrees Centigrade was adopted as a routine temperature for raising adults. The males developed faster than the females, the increase in development speed being demonstrable from the second larval stage on.

Longevity of the *Haemagogus* mosquitoes is discussed in detail. Individual mosquitoes were kept in glass vials with a layer of moist cotton covered with filter paper on the bottom and the vial plugged with a cup of aluminum (or monel) wire screening. The best results were obtained in a relatively dry atmosphere (70 per cent relative humidity) with a constant air movement provided by an electric fan. Studies were made on the effect of temperature on *Haemagogus* adults along with the temperature effect on yellow fever virus development.

Throughout the paper, the author compares the diurnal forest mosquitoes *(Haemagogus)* with other species. The relation between the laboratory results and the habits of the mosquito in nature is discussed, together with some comment on the significance of the concept of "optimum temperature."—Abby H. Casanges, Beltsville, Md.

Biological Characteristics of Laboratory-Reared *Aedes atropalpus.* By H. L. Trembley. Jour. Ec. Ent. 40(2):244–250. 1947.

Aedes atropalpus, a species of rock-hole mosquito, has been added to that small group of mosquitoes which are autogenous. The females do not require blood meals, or, in fact, any food at all, in order to deposit viable eggs. A colony in which the females were fed only a sugar solution was reared in the laboratory for more than a year, and in its 26th generation continued with no apparent loss of vigor. A colony in which the females received only distilled water for several generations was thriving at the time the article went to press. A comparison of the life-cycles of individuals from the colony routinely offered blood and those denied blood showed no marked differences. The females of this species may be induced to bite when blood meals are offered, but subsequent oviposition results in comparatively few viable eggs. *Aedes atropalpus* may mate in small spaces, has no seasonal period of comparative inactivity, and does not exhibit a decrease in the number of females with the increase in successive generations.—Author's abstract.

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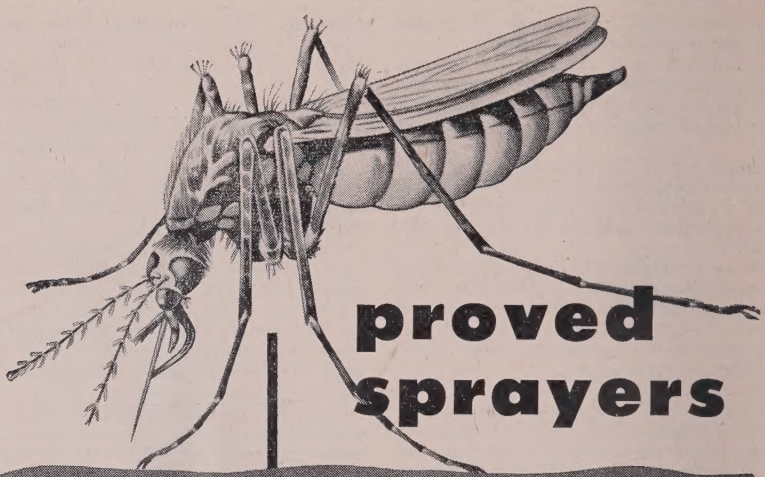

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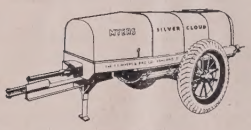

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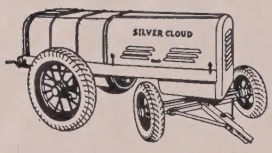

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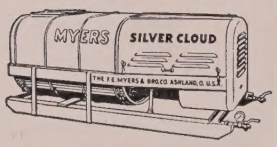

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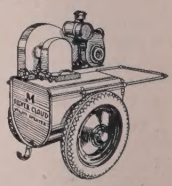

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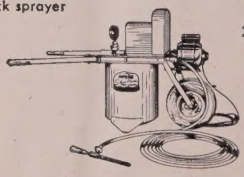

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